automotive power train systems

Jay Webster

AN PUBLICATION

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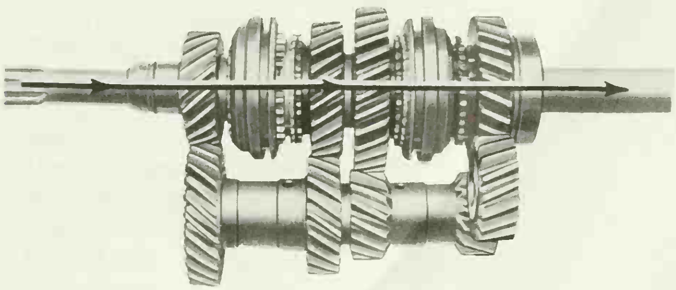

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Note To The Student

AUTOMOTIVE POWER TRAIN SYSTEMS is designed to give a comprehensive introduction to power trains. Each component area is covered twice: in an introductory operations unit and in a service procedure unit. For example, the **Manual Clutch** unit is followed by a **Manual Clutch Service** unit. The service units begin with Developing Job Competencies.

Operations units tell how the component works.

Service units cover preventive maintenance, troubleshooting, and service. Specific information is given for specific service jobs. **Tech Checks** in the service units, relate problems to possible causes and give the service needed.

All units list key goals to be achieved. **New Terms** are given at the end of the unit. General test questions are given on operations and service jobs. In addition, **Certification Practice** questions are given. These questions are similar to those used on National Institute for Automotive Service Excellence (NIASE) examinations. Answers to these questions are given at the end of the test. These questions are designed to prepare you for certification in the power train area.

Each unit also has **Discussion Topics and Activities.** These give additional study and work in each area.

The concluding unit in the book, **On the Job,** gives information on careers and describes what a power train specialist does on the job.

A **Glossary** at the end of the book defines all key terms.

SAFETY — Learning safe working practices and developing proper attitudes concerning safety is essential to today's auto mechanic. Working as a mechanic requires the ability to diagnose automotive problems and safely and efficiently make repairs or replacements as required.

In AUTOMOTIVE POWER TRAIN SYSTEMS, safety is stressed throughout and proper working practices are emphasized as new material is presented.

Always be sure that you are aware of potential hazards when working on automobiles. If you have any doubts about a particular operation, check with your instructor *before* beginning the job. Remember, you must be concerned with your personal safety and the safety of your classmates as well as the safe-working operation of the automobiles assigned to you for repair.

See your instructor whenever you have any questions about safety.

The Publisher

Job Competencies

Manual Clutch Service

3-1 Lubricate clutch linkage.
3-2 Adjust clutch pedal free play.
3-3 Perform a clutch road test and noise diagnosis.
3-4 Remove a clutch.
3-5 Clean and inspect clutch components.
3-6 Check clutch housing for misalignment.
3-7 Replace a clutch release bearing.
3-8 Install a new pilot bearing.
3-9 Install the clutch.
3-10 Service the clutch and slave cylinder.
3-11 Bleed a hydraulic clutch system.

Manual Transmission Service

5-1 Identify a transmission model.
5-2 Drain and refill manual transmission lubricant.
5-3 Perform a road test and diagnose trouble.
5-4 Adjust shifting linkage.
5-5 Replace an extension housing rear seal.
5-6 Remove a transmission.
5-7 Disassemble a manual transmission.
5-8 Clean and inspect transmission parts.
5-9 Reassemble a manual transmission.
5-10 Install a manual transmission.

Overdrive Transmission Service

7-1 Check overdrive lubricant level.
7-2 Drain lubricant, clean the filter, and refill the overdrive lubricant.
7-3 Perform an overdrive trouble diagnosis.
7-4 Remove an overdrive assembly for service.
7-5 Disassemble an overdrive unit.
7-6 Clean and inspect overdrive parts.
7-7 Reassemble an overdrive unit.
7-8 Install an overdrive assembly.

Drive Shaft Assembly Service

9-1 Lubricant a universal joint.
9-2 Inspect a drive shaft assembly for wear.
9-3 Check a drive shaft for runout.
9-4 Measure and adjust universal-joint operating angle.
9-5 Balance a drive shaft.
9-6 Overhaul a simple universal joint.
9-7 Overhaul a constant-velocity universal joint.
9-8 Remove and replace a drive shaft center support bearing.

Overdrive Transmission Service

11-1 Drain, refill, and check differential lubricant level.
11-2 Perform a differential road test and noise diagnosis.
11-3 Replace a pinion seal.
11-4 Remove a carrier assembly.
11-5 Disassemble a carrier assembly.
11-6 Clean and inspect differential components.
11-7 Check pinion depth.
11-8 Install pinion and measure pinion preload.
11-9 Reassemble the case.
11-10 Adjust differential bearing end play and check runout.
11-11 Install case and adjust backlash.
11-12 Check ring and pinion gear tooth contact pattern and replace assembly.
11-13 Service a cone clutch limited-slip differential case.
11-14 Service a multiple-disc limited-slip differential case.

Drive Axle Service

13-1 Remove and replace a rear-drive axle.
13-2 Remove and replace a rear-drive axle seal.
13-3 Remove and replace a rear-drive axle bearing.
13-4 Remove and replace a front-drive axle.
13-5 Overhaul or lubricate a front-drive axle flexible joint.

Manual Transaxle Service

15-1 Check, drain, and refill the lubricant in transaxle.
15-2 Perform a transaxle road test and trouble diagnosis.
15-3 Adjust transaxle shifting control.
15-4 Remove a transaxle from a vehicle.
15-5 Disassemble a transaxle.
15-6 Reassemble the transaxle.
15-7 Install the transaxle in a vehicle.

Transfer Case Service

17-1 Check, drain, and refill the lubricant in a transfer case.
17-2 Perform a trouble diagnosis on a transfer case.
17-3 Remove a transfer case from a vehicle.
17-4 Disassemble a transfer case.
17-5 Reassemble a transfer case.
17-6 Install a transfer case in a vehicle.

Looking Up Specifications

One of the most important activities of a power train repair job is locating and following the correct service procedures and specifications. Specifications are measurements recommended for components by the car manufacturer. The mechanic uses power train specifications and step-by-step procedures as a guide while doing the repair. You must be able to locate and follow these procedures and specifications.

The most up-to-date specifications and detailed step-by-step procedures are found in a service manual. A service manual covers one year and make of vehicle. The manual shown in Figure A contains information about the 1980 Pontiac Phoenix.

The first step in looking up specifications is determining the make and year of the car you are servicing. Determining the make of the vehicle is a simple matter of looking for the name (Chevrolet, Toyota, etc.) on the trim on the outside of the vehicle. The year of the car can be found by checking the registration inside the vehicle.

The next step is to locate the appropriate shop manual for this model and year vehicle, and to open the manual to the table of contents as shown in Figure B. The mechanic refers to the table of contents for the section that concerns the unit being serviced. For example, let's assume you are servicing a transaxle unit. Look in the table of contents for the section on transaxles. (In the manual shown in Figure B, the section is numbered 21.) Turn in the manual to the appropriate section.

When the correct section has been located, the mechanic will find two types of information presented: step-by-step repair techniques and specification charts. The step-by-step repair instructions usually explain with pictures how to disassemble or take apart a component, how to repair it, and how to reassemble and adjust it. These procedures are usually numbered in the order they are to be performed. The mechanic must learn to do things in sequence.

Figure A. Specifications and step-by-step procedures are found in a service manual.

Figure B. The Index in the service manual shows what section the mechanic must turn to for specifications. (Chrysler)

TIGHTENING REFERENCE

A-412 Manual Transaxle	Thread Size	Torque Newton Metres	Torque Inch-Pounds
Case—Clutch Housing Bolt	M 8 x 1.25	28	250
—Clutch Housing Stud	M 8 x 1.25	28	250
—Release Bearing End Cover Screw (4)	M 7 x 1.00	12	105
Back-up Light Switch	M12 x 1.50	16	144
Electronic Timing Probe Retainer	M36 x 1.50	9	80
Cover—Gearshift Selector Shaft	M60 x 1.50	47	35*
~~Gearshift Detent Body Lock Nut~~	~~M12 x 1.50~~	~~20~~	~~175~~
Drain Plug	M24 x 1.50	20	175
~~Fill Plug~~	~~M24 x 1.50~~	~~20~~	~~175~~
Pinion Shaft Bearing Retainer Bolt (4)	M 8 x 1.25	39	29*

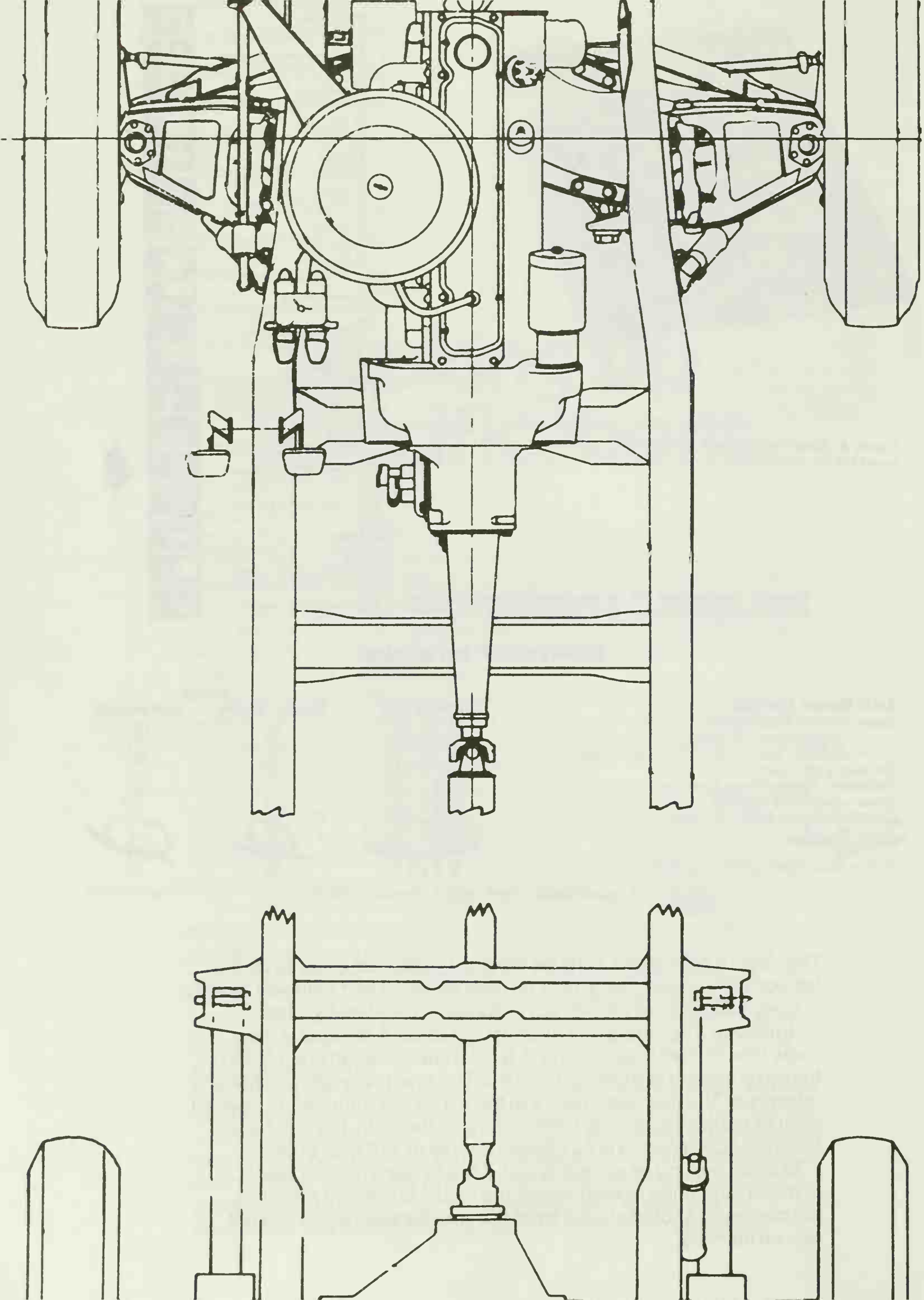
* foot-pounds

Figure C. A specification chart from a service manual. (Chrysler)

The various operations must be done in the correct order to do the job correctly. Instructions must be read carefully and followed exactly.

Specifications are usually not included in the step-by-step instructions. They are given in charts or tables. A mechanic must know how to read these charts. A typical specification chart from the transaxle section is shown in Figure C. This chart provides a tightening reference. The mechanic refers to the list for the information needed, such as drain plug torque. Then looking to the right, the mechanic finds the specification is 20 newton metres or 175 inch pounds.

To avoid making an error, it is advisable to use a ruler or piece of paper as a guide to read across the chart. To prevent mistakes, the mechanic should always **write the specification down** and not rely on memory.



Unit 1
Introduction

The engine, sometimes called a *power plant* or a *motor,* provides power to drive the automobile. In most automobile engines, the explosive power of a mixture of air and gasoline or air and diesel fuel drives down pistons. The pistons turn a crankshaft to which they are attached.

The *power* developed by the engine must be carried to the driving wheels whose turning makes the automobile move. This is the job of a number of components which are called the *power train,* (Figure 1-1.)

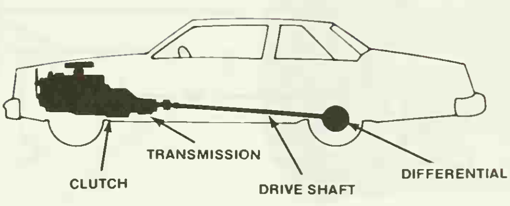


Figure 1-1. The power train delivers the engine's power to the driving wheels. (General Motors Corporation)

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Define the terms **torque, power,** and **power flow.**
2. Describe the purpose of the main power train components.
3. Describe the different types of drive train arrangements.
4. Describe the career opportunities in the field of power trains.
5. Explain how to prepare for a career.

TORQUE, POWER, AND POWER FLOW

Several basic terms are used in nearly all discussions of power trains. One of these terms is **torque.** When the burning of fuel takes place in the engine's cylinder, the pistons and connecting rods force the crankshaft to turn. This rotary unit of force is called torque. One of the main purposes of the power train is to increase the torque developed by the engine.

Torque, in simple terms, is turning or twisting effort. When a mechanic uses a wrench to tighten a bolt (Figure 1-2) torque is applied to the bolt. When the bolt is tight, the mechanic may not be able to turn it any more. Even though the bolt does not turn, the mechanic is applying torque. Torque, then, is a force that produces, or tries to produce, rotation.

The term **power** is often confused with **torque.** Power is the rate or speed of doing work. Power adds the idea of time. The more quickly work is done, the more power is involved. For example, we could hitch a horse up to a rope and pulley to lift a container of coal as shown in Figure 1-3. It would take a certain amount of time for the horse to lift up the coal. If we hitch up two horses to the rope as shown in Figure 1-4, we might be able to get the coal up in half the time. With two horses we have twice as much power.

As we describe the operation of components of the power train we will be concerned with the flow of power. The flow of power, or **power flow,** is the path the power takes from the engine to the wheels that drive the automobile. Understanding the power flow through a power train component is basic to understanding how the component works. The mechanic must understand how a component works in order to properly diagnose and repair a power train malfunction.

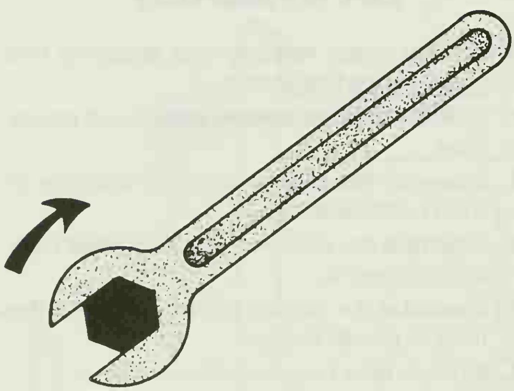


Figure 1-2. Torque is a turning or twisting force.

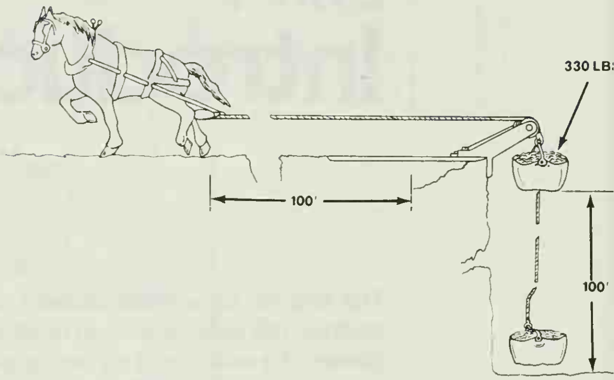


Figure 1-3. The faster the horse pulls up the coal, the more the power developed.

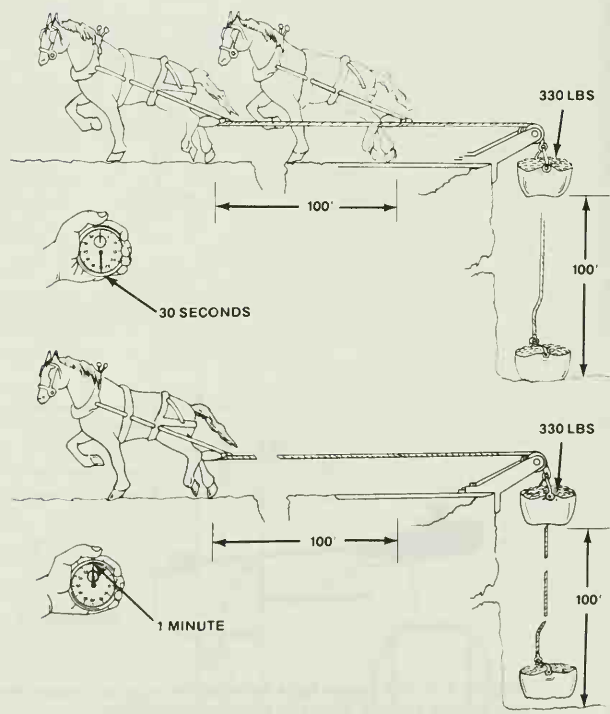


Figure 1-4. Two horses pull the coal up in half the time with twice as much power.

POWER TRAIN COMPONENTS

There are many different types and variations of power train systems. However, most of these systems have the same basic components. The power train system has:

CLUTCH The purpose of the manually operated **clutch** (Figure 1-5) is to couple and uncouple the engine from the power train. When you crank the engine for starting, the engine must be disconnected from the power train. Uncoupling the engine from the power train also makes shifting the transmission easier and allows the engine to run with the transmission in gear while stopped.

MANUAL TRANSMISSION There are two basic types of transmissions: manually operated transmission and automatic transmission. An **automatic transmission** is one in which the shifting is done automatically according to road and engine load conditions. The **manual** or **standard transmission** is shifted by the driver. In this book we cover the manual transmission.

A manual **transmission** (Figure 1-6) is a housing containing a number of gears. It is usually bolted to the rear of the engine. The engine's power goes through the clutch and into the transmission. The transmission increases the engine's turning effort, or torque, to get the automobile moving. Torque is multiplied by the gears in the transmission. Another important job of the transmission is to provide a gear that allows the automobile to back up.

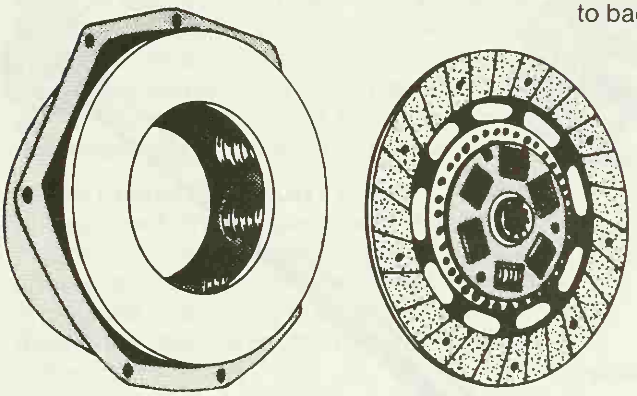


Figure 1-5. The manually operated clutch couples and uncouples the engine from the power train.

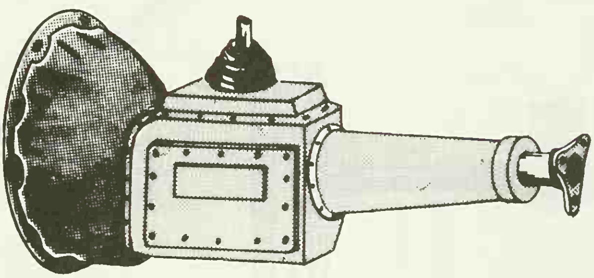


Figure 1-6. A manual transmission houses a number of gears.

DIFFERENTIAL The purpose of the **differential** (Figure 1-7) is to allow the drive wheels to turn at different speeds when the automobile goes around a corner. This is necessary because, when cornering, the wheel on the inside of the turn goes through a smaller arc or corner than the wheel on the outside. If the wheels are not allowed to turn at different speeds, they will tend to skip around the corner, and steering will be very difficult. The differential also provides another gear-reduction torque increase for the engine's power.

TRANSAXLE Automobiles with a front engine and front-wheel drive or a rear engine and rear-wheel drive normally combine the transmission and differential assembly into one unit. When they are combined, the assembly is called a **transaxle** (Figure 1-8).

DRIVE AXLES In order for the car to move, power must get to the wheels that provide the drive. **Drive axles** (Figure 1-9) are used to transfer the power from the differential to the drive wheels.

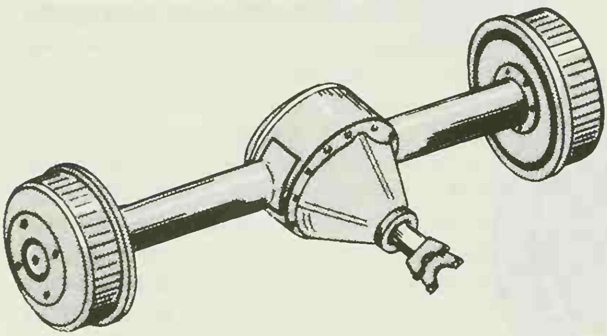


Figure 1-7. The differential allows the drive wheels to turn at different speeds when turning.

Figure 1-9. Drive axles transfer power from the differential to the drive wheels.

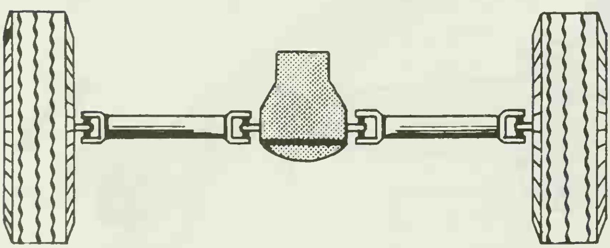


Figure 1-8. The transaxle combines the transmission and differential assembly into one unit.

DRIVE SHAFTS When the transmission and differential are not combined in one housing, power is transferred from one unit to the other. This is the job of the **drive shaft assembly** (Figure 1-10). Getting the power from the transmission to the differential assembly is handled by a large shaft, the drive shaft. The drive shaft is connected to the output shaft of the transmission at one end and the differential at the other.

POWER TRAIN ARRANGEMENTS

The basic power train components may be arranged differently in different vehicles. Four common power train arrangements are:

FRONT ENGINE, REAR DRIVE A front-engine, **rear-drive** arrangement is shown in Figure 1-11. The engine is mounted in the front of the vehicle. The rear wheels are used to drive the vehicle. The clutch and transmission are mounted at the rear of the engine. A drive shaft is used to transfer the power to the differential mounted in the rear of the car. Drive axles transmit the power from the differential out to each rear wheel.

FRONT ENGINE, FRONT DRIVE A front-engine, **front-drive** arrangement is shown in Figure 1-12. The transmission and differential are combined into a transaxle. The transaxle is mounted directly to the engine. Drive axles deliver the power from the transaxle to each of the front wheels.

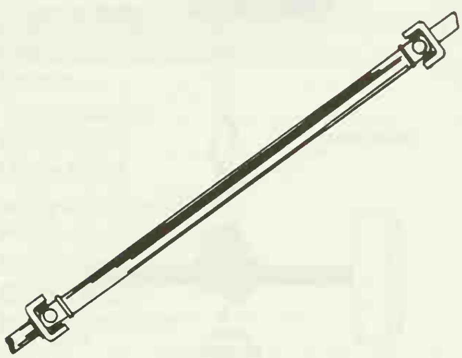


Figure 1-10. The drive shaft transfers power from the transmission to the differential assembly.

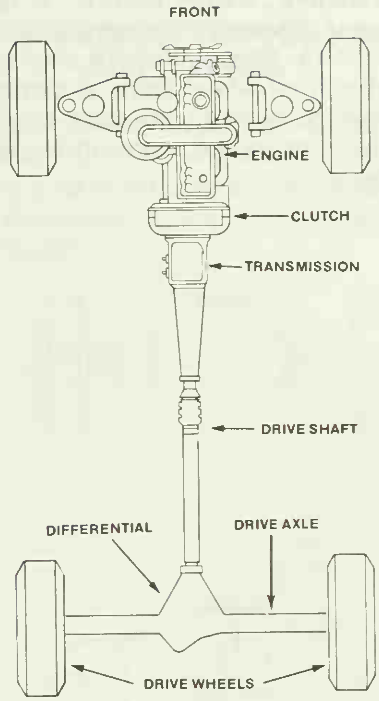


Figure 1-11. A front-engine, rear-drive arrangement.

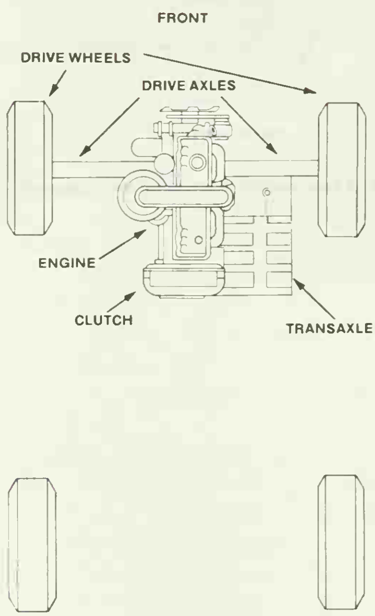


Figure 1-12. A front-engine, front-drive arrangement.

REAR ENGINE, REAR DRIVE A rear-engine, rear drive arrangement is shown in Figure 1-13. This system is similar to that used in front-wheel drive. A transaxle is mounted directly to the rear engine. Drive axles provide the power to the rear-drive wheels.

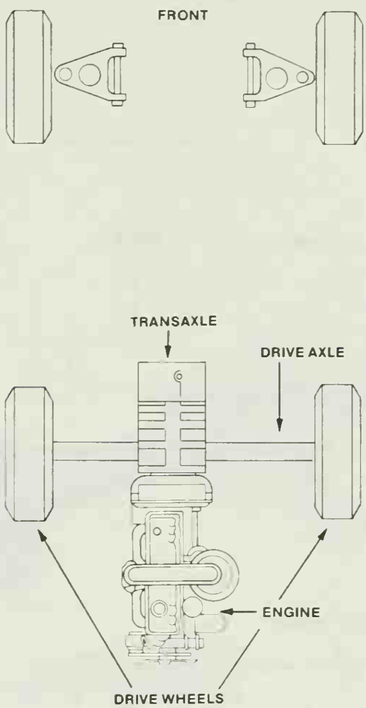


Figure 1-13. A rear-engine, rear-drive arrangement.

FOUR-WHEEL DRIVE It is possible to have a drive arrangement in which all four wheels are driven by the engine. A **four-wheel drive** arrangement is shown in Figure 1-14. To get four wheels into drive, a few more components are added to the conventional system. The front driving axle must have universal joints at the steering spindles so that the wheels can be turned for steering at the same time they are being driven. There must also be a second drive shaft to get engine power to the front driving axle. A transfer case is coupled to the output of the transmission. The transfer case transmits engine power to the rear wheels alone for two-wheel drive or to the front and rear wheels for four-wheel drive.

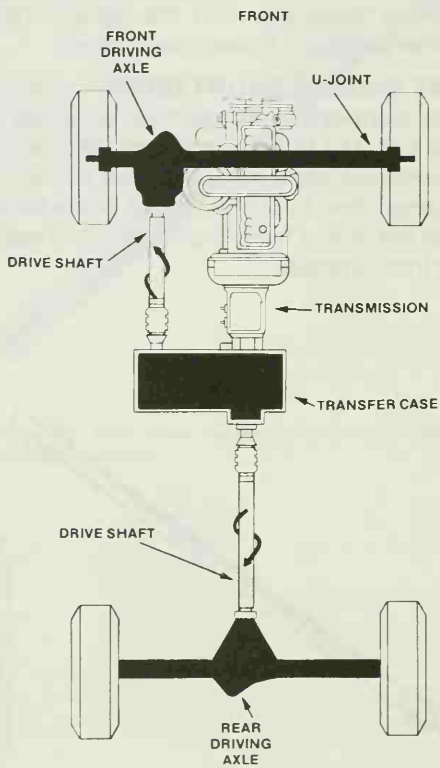


Figure 1-14. A four-wheel drive arrangement.

CHECK YOURSELF

1. What is the purpose of the power train?
2. Define the term torque.
3. Define the term power.
4. Why is the power flow through a power train component important?
5. What is the purpose of the clutch?
6. What is the purpose of the transmission?
7. What is a transaxle?
8. What is the purpose of a differential?
9. What is the purpose of the axle shaft?
10. What is the purpose of a drive shaft?

CERTIFICATION PRACTICE

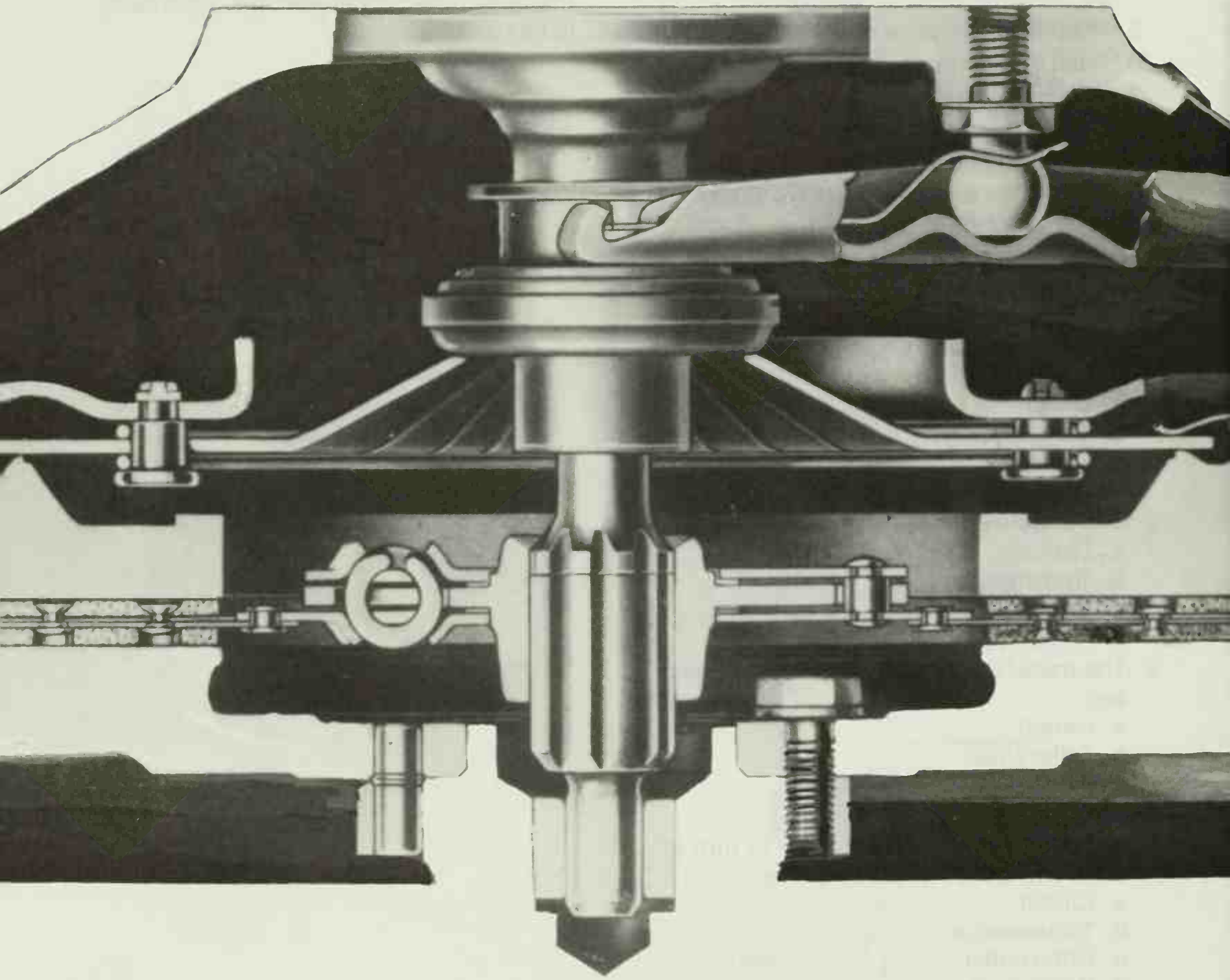
1. The power train component that couples and uncouples the engine from the power train is:
   a. Clutch
   b. Transmission
   c. Transaxle
   d. Differential
2. The engine's torque is multiplied by the:
   a. Clutch
   b. Transmission
   c. Drive shaft
   d. Axle shaft
3. The transaxle combines the transmission and:
   a. Clutch
   b. Differential
   c. Drive shaft
   d. None of the above
4. The drive wheels are allowed to turn at different speeds because of the:
   a. Clutch
   b. Transmission
   c. Differential
   d. Drive shaft
5. A transaxle is used with:
   a. Front-wheel drive
   b. Four-wheel drive
   c. Both a and b
   d. Neither a nor b

ANSWERS:

1. a, 2. b, 3. b, 4. c, 5. a

DISCUSSION TOPICS AND ACTIVITIES

1. Raise a vehicle on a hoist. Identify the main power train components.
2. Make a list of vehicles which use each of the power train arrangements described in this unit.



Unit 2
Manual Clutch

A **manual clutch** is required on a vehicle with a manually shifted transmission. The function of the clutch is to connect and disconnect the engine from the transmission. The engine must be disconnected from the transmission so that the driver can crank-start the engine. The clutch also allows the driver to shift the transmission more easily. The clutch also allows the engine to run with the transmission in gear. In this unit we will see how a manual clutch operates.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe the basic components and operation of a manual clutch.
2. Identify the parts of a clutch disc.
3. Explain the operation of a coil-spring pressure plate assembly.
4. Explain the operation of a diaphragm-spring pressure plate assembly.
5. Identify the parts and explain the operation of a mechanical and hydraulic clutch linkage.

BASIC CLUTCH COMPONENTS AND OPERATION

The manual clutch disconnects the engine from the power train when the driver pushes down the clutch pedal. As the pedal comes up, the engine connects to the power train, and the automobile can move. The clutch must be designed so that this connecting and disconnecting or engaging and disengaging is smooth.

The clutch must engage gradually. It must not jump abruptly from no connection at all to a direct, solid connection. To move a car we must speed up the engine to get enough power to move. We cannot in one moment bring the speed of the wheels up to the speed of the engine.

Shifting gears in a moving car creates a similar situation—the wheels are not turning at the same speed as the engine. We need something that will slip a little, take hold gently at first, and gradually grab harder and harder. Thus the rear wheels can start to move slowly and gradually pick up speed, until finally everything is turning at the same rate and the clutch is solidly engaged. From then on, of course, we do not want any slipping, because that is just wasting power and fuel.

The type of clutch used on most automobiles is called a **single dry-disc clutch.** It is one plate squeezed tightly between two other plates, as in Figure 2-1. The middle plate is driven. A strong spring or set of springs forces the two driving members together. This tightens their grip on the middle plate until all are turning together as one unit.

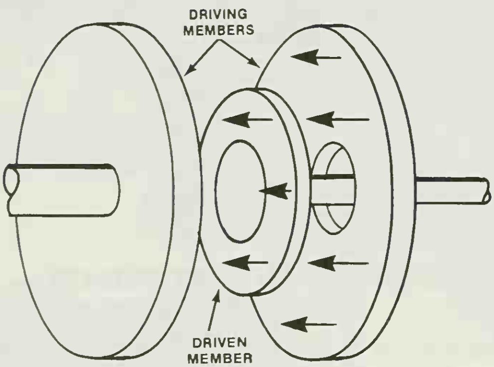


Figure 2-1. Single dry-disc clutch. (General Motors Corporation)

The engine **flywheel** is used for one of the driving members. Its surface is machined very smooth where the friction plate pushes up against it. The other driving member is called the **pressure plate.** It is a heavy ring of cast iron, smooth on one side. The pressure plate is fastened to the **clutch cover,** which is bolted to the flywheel, so they all turn together. The pressure plate can slide back and forth. A flywheel and pressure plate are shown in Figure 2-2.

The driven plate is a flat disc of steel with friction facing on each side. The disc is fastened by splines to a shaft going to the transmission. Since the **clutch disc** has internal splines, Figure 2-3, it fits on the transmission input shaft and must rotate when the input shaft rotates. The clutch disc is free to move back and forth on the input shaft due to the straight splines.

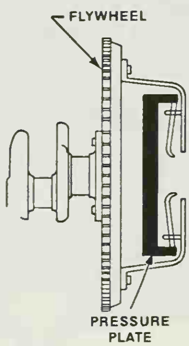


Figure 2-2. The flywheel and pressure plate are the driving members in the clutch. (General Motors Corporation)

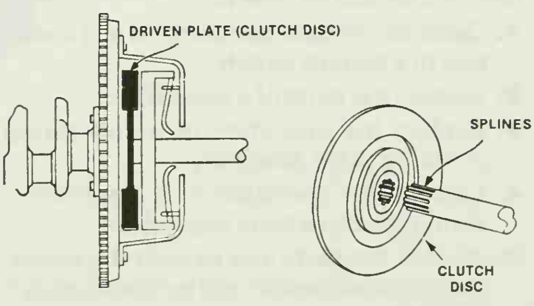


Figure 2-3. The driven member in the clutch fits between the pressure plate and the flywheel on a splined shaft. (General Motors Corporation)

When the driver's foot is off the clutch pedal, the pressure plate assembly pushes the clutch disc against the flywheel. The disc is squeezed between the pressure plate and flywheel. It is forced to turn with the flywheel and drive the transmission input shaft, Figure 2-4.

When the driver pushes down the clutch pedal, the pressure plate is forced away from the flywheel. The clutch disc is disengaged from the pressure plate and flywheel. The engine no longer drives the clutch disc and transmission input shaft, Figure 2-5. The three main parts of a clutch assembly are shown in Figure 2-6.

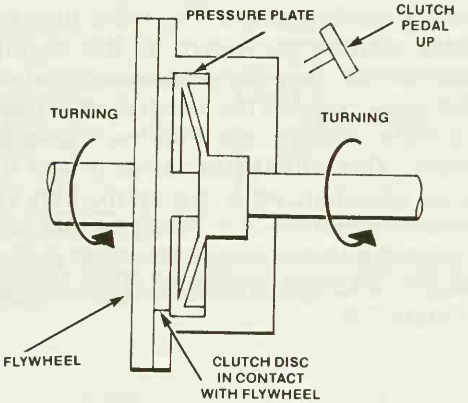


Figure 2-4. When the pedal is up, the flywheel and pressure plate drive the clutch disc.

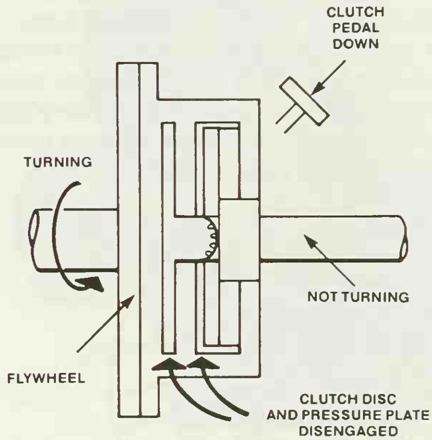


Figure 2-5. When the pedal is pushed down, the disc is disengaged from the pressure plate and flywheel.

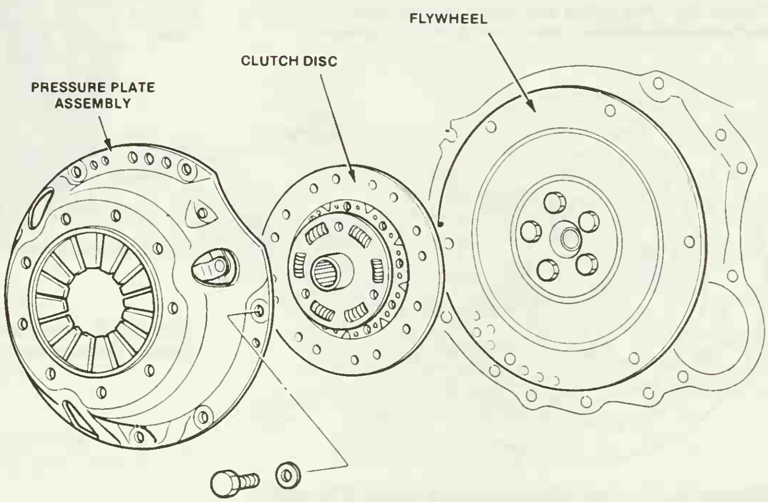


Figure 2-6. The three main parts of a clutch assembly. (Nissan Motor Corporation in USA)

CLUTCH DISC

The friction disc, Figure 2-7, has a splined hub which is free to slide lengthwise along the splines of the clutch shaft, but which drives the shaft through these same splines. When the parts disengage, a vacuum may form, causing the disc to stick to the flywheel or pressure plate. Grooves on both sides of the disc lining prevent the disc from sticking. The clutch friction disc is usually made of a number of flat segments. Friction **facings** are attached to each side of the disc with brass rivets. These facings must be heat resistant since friction produces heat. The most commonly used facings are made of cotton and asbestos fibers woven or molded together and mixed with resins. Very often, copper wires are woven or pressed into the material to give it additional strength.

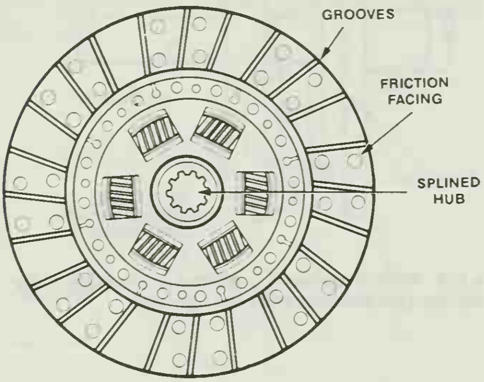


Figure 2-7. The clutch disc has a splined hub and friction surfaces on each side. (American Motors Corporation)

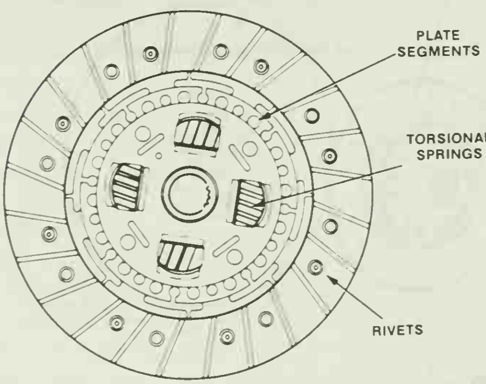


Figure 2-8. Torsional vibration springs are used to smooth out the power flow through the clutch. (American Motors Corporation)

The clutch disc usually has a flexible center to absorb the torsional vibration of the crankshaft. This prevents the vibration from being transferred to the power train. The flexible center is usually made from steel **torsion springs** placed between the hub and the steel plate, Figure 2-8. The springs allow the disc to rotate slightly in relation to its hub until the springs are fully compressed and relative motion stops. Then the disc can rotate slightly backward as the springs decompress. This slight backward and forward rotation allows the clutch shaft to rotate at a more uniform rate than the crankshaft rotates. This eliminates some of the torsional vibration from the crankshaft and prevents vibration from being carried back through the transmission. The main parts of a clutch disc are shown in cross-section in Figure 2-9.

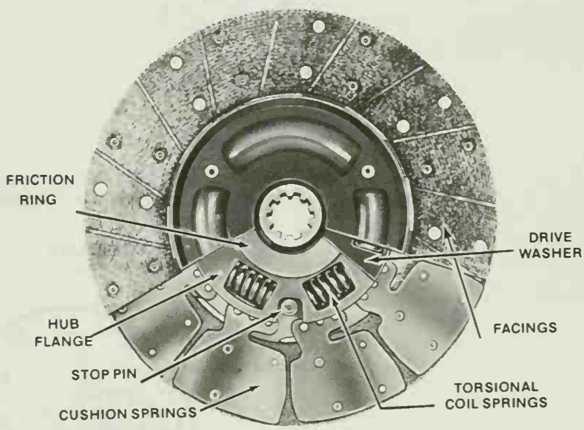


Figure 2-9. Cross-sectional view of a clutch disc. (General Motors Corporation)

RELEASE BEARING

The clutch **release bearing,** Figure 2-10, is a ball-thrust-bearing and thrust-face assembly contained in the clutch housing, mounted on a sleeve, Figure 2-11, attached to the front of the transmission case. The release bearing is moved by a **clutch fork,** Figure 2-12, to contact the release levers and move the pressure plate to the rear, thus separating the clutch driving members from the driven member when the clutch pedal is depressed by the driver. The release bearing is often mounted to the **release fork** with retaining springs on each side of the sleeve. The relationship of the release bearing and clutch fork to the other clutch components is shown in Figure 2-13.

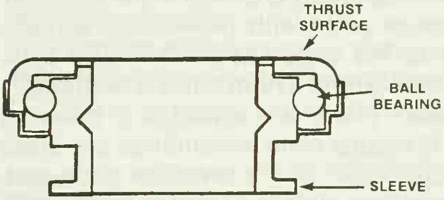


Figure 2-10. The release bearing contains ball bearings between a sleeve and a thrust surface. (Chevrolet Motor Division of General Motors Corporation)

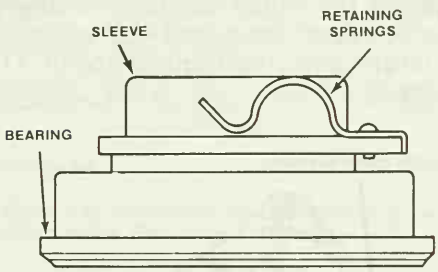


Figure 2-11. The release bearing is often mounted to the clutch fork with retaining springs. (American Motors Corporation)

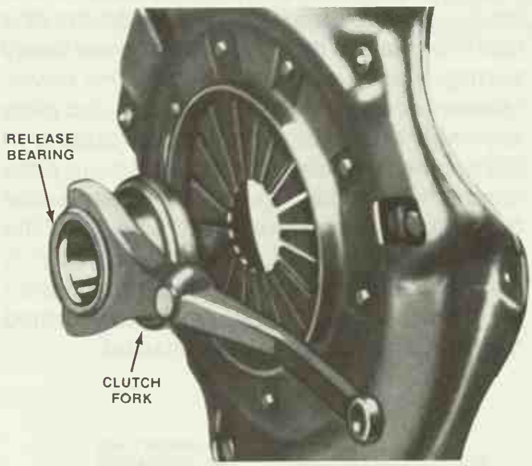


Figure 2-12. The release bearing is mounted on the clutch fork. (Chevrolet Motor Division of General Motors Corporation)

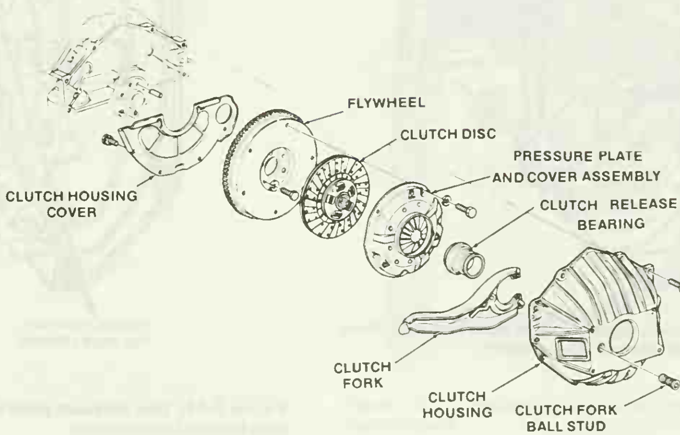


Figure 2-13. Parts of the clutch and release system. (General Motors Corporation)

COIL-SPRING PRESSURE PLATE ASSEMBLY

In order to start the clutch disc and transmission input shaft turning, an assembly called a **pressure plate** forces the clutch disc against the engine flywheel. There are two basic types of pressure plate assemblies: coil-spring or diaphragm-spring. The type depends on the kind of spring used to push the clutch disc against the flywheel.

A **coil-spring pressure plate** assembly with three coil springs is shown in Figure 2-14. The pressure plate assembly is made up of a cast-iron plate, a heavy stamped cover, heavy springs between the plate and the cover, release levers, and links. The cover and plate assembly are bolted to and must rotate with the engine flywheel. When the pressure plate assembly is bolted to the flywheel, it squeezes the clutch disc between the flywheel and the pressure plate. Since the clutch disc is mechanically connected to the transmission input shaft, a solid connection is now formed from the engine to the transmission.

When the pressure plate is in an engaged position, the springs push forward to squeeze the disc against the flywheel. The force is between 1000 and 3000 pounds, depending on the number and size of the springs in the pressure plate. The clutch pressure plate springs are under pressure when the clutch cover is assembled to the pressure plate. The springs are compressed even farther when the assembly is bolted to the flywheel. A pressure plate with twelve coil springs, similar to the plate shown in Figure 2-15, is common where a high force is required.

Pressure plates are available in different sizes. Pressure plate assemblies are sized by the diameter of the pressure plate unit. If the pressure plate is 10 inches in diameter, it is described as a 10-inch clutch. The larger the pressure plate, the larger the diameter of the clutch disc used. The larger the pressure plate and disc, the more torque and horsepower the clutch can handle. Small, light vehicles can use 8- or 9-inch clutches while larger vehicles require 10- or 11-inch units.

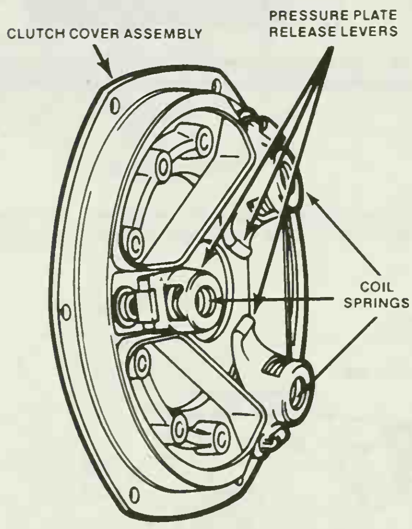


Figure 2-14. A coil spring pressure plate assembly with three coil springs. (American Motors Corporation)

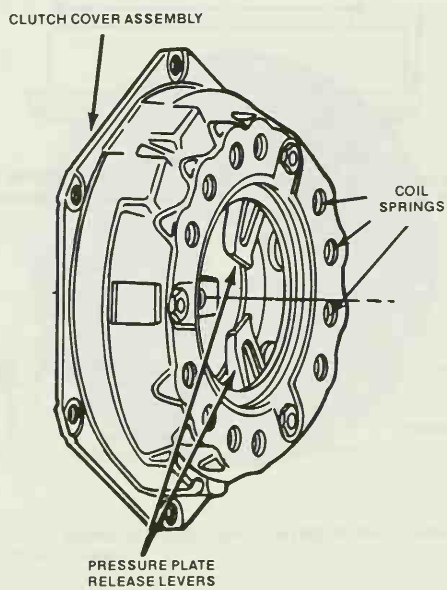


Figure 2-15. This pressure plate uses 12 coil springs. (American Motors Corporation)

A cross-sectional view of a coil-spring pressure plate assembly and disc is shown in Figure 2-16. Clutch release or uncoupling is done by removing the spring pressure from the clutch disc. Equally spaced clutch release levers are fastened to the clutch pressure plate cover in a way that allows them to pivot on the cover attachment. A short distance beyond this pivot point is a second attaching hole that is fastened to the pressure plate.

When the clutch pedal is depressed, the release bearing is moved toward the flywheel and contacts the inner ends of the release levers (A in Figure 2-17). Each release lever is pivoted on a floating pin (B) which remains stationary in the lever and rolls across a short flat portion of the enlarged hole in the eyebolt (C). The outer end of each release lever engages the pressure plate lug (D) by means of a strut (E), which provides knife edge contact between the outer end of the lever and the lug. The outer ends of the eyebolts extend through holes in the stamped cover (F), and are fitted with adjusting nuts (G), to correctly position the levers.

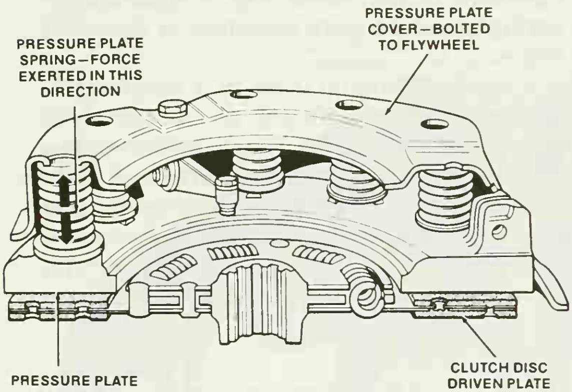


Figure 2-16. Cross-sectional view of a coil-spring pressure plate and disc. (Ford Motor Company)

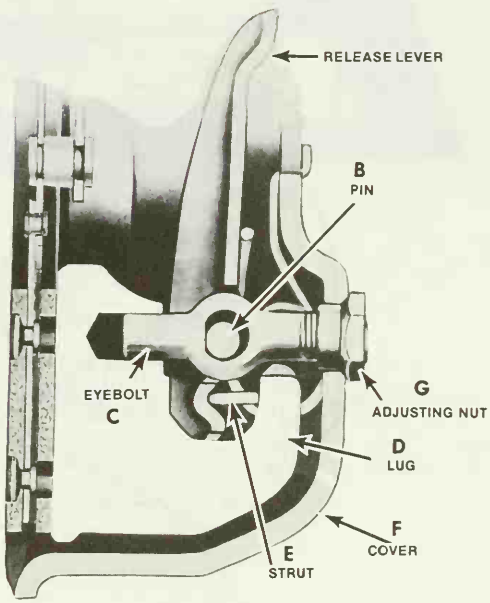


Figure 2-17. Release lever operation. (General Motors Corporation)

When the clutch system is fully engaged, the clutch disc is firmly clamped between the flywheel and the pressure plate by the pressure of the springs. When the driver disengages the clutch by depressing the pedal, the release fork is moved on its pivot, and the pressure is applied to the release bearing. The rotating race of the release bearing presses against the clutch release levers and moves them on their pivot pins. The outer end of the release levers, being fastened to the cover, move the pressure plate to the rear. This compresses the clutch springs and allows driving members to rotate independently of the driven member. The release fork moves only on its pivot, which contacts the clutch-fork ball stud. All parts of the clutch system, except the clutch release bearing and collar, rotate with the flywheel when the clutch is engaged.

When the clutch is disengaged, the release bearing rotates with the flywheel, but the driven plate and the clutch shaft rotate as determined by the transmission gear range and vehicle speed.

DIAPHRAGM-SPRING PRESSURE PLATE ASSEMBLY

In a **diaphragm-spring-type clutch,** a diaphragm is used instead of coil springs. A diaphragm is a conical piece of spring steel punched to give it greater flexibility. The diaphragm is placed between the cover and the pressure plate so that the diaphragm spring is nearly flat when the clutch is engaged. The action of this type of spring is similar to an oil can. If you push in on the center of the can top, the outside rim moves out. When you release the pressure, the outside rim returns. A diaphragm spring operates in the same way. A **diaphragm-spring pressure plate** assembly is shown in Figure 2-18.

A cross-sectional view of a diaphragm-spring pressure plate and disc assembly is shown in Figure 2-19. The outer rim of the diaphragm is mounted to the pressure plate and is pivoted on rings approximately one inch in from the outer edge so that pressure at the inner section will cause the outer rim to move away from the flywheel and draw

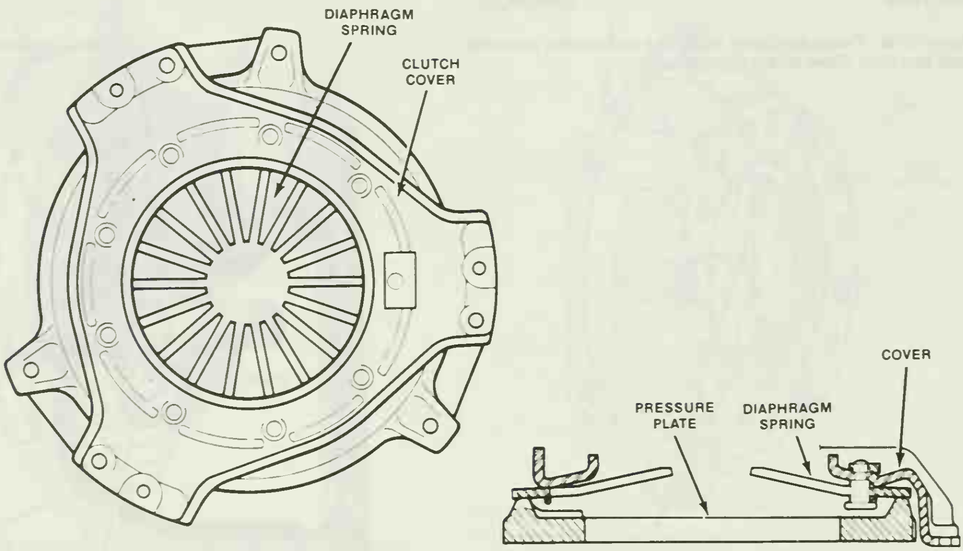


Figure 2-18. Diaphragm-spring pressure plate assembly. (American Motors Corporation)

the pressure plate away from the clutch disc, releasing or disengaging the clutch. When the pressure is released the inner section moves out, and the movement of the outer rim forces the pressure plate against the clutch disc, engaging the clutch.

Figure 2-19 also shows the **pilot bushing.** This bushing supports the end of the transmission input shaft or clutch shaft and centers the clutch disc. The unit may be a bushing or a bearing installed in the crankshaft or flywheel.

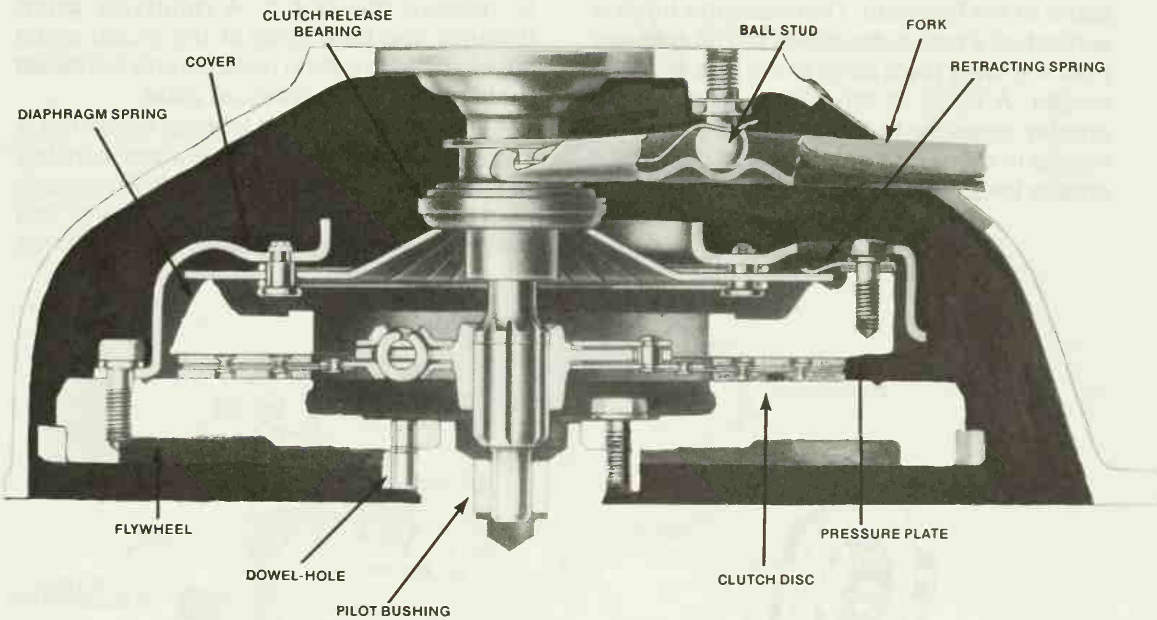


Figure 2-19. Cross-sectional view of a diaphragm-spring pressure plate and disc assembly. (General Motors Corporation)

SEMI-CENTRIFUGAL CLUTCH

Some automotive clutches are called **semi-centrifugal** because centrifugal force is used to increase the spring force against the friction disc. An added force can be gained by reshaping the release levers and adding a weight to their outer ends.

As shown in Figure 2-20, when the speed of the engine increases, the centrifugal force acting on the weights of the release levers tries to throw the weights out to a greater diameter. The weights are held, however, and pivoted at a point revolving about the lever pivot point. The weights and pivot points are not on the same plane as the rotating plane of the flywheel. Therefore the force is applied on a radius described by the distance from the lever pivot point to the center of the weight. A force in this direction applies a greater pressure to the pressure plate. This results in more grip on the clutch disc and a greater torque-carrying capacity of the clutch.

MECHANICAL CLUTCH LINKAGE

The release-bearing and fork assembly must be connected to the driver's pedal to allow the driver to engage and disengage the clutch. The connection is made by a set of linkages called the **clutch linkage.** The clutch linkage may operate mechanically or with vacuum, electrical, or hydraulic assistance. The two most common types of clutch linkage are mechanical and hydraulic.

Most pressure plate assemblies require about 500 pounds of force to depress the release fingers. With the **mechanical clutch linkage** and its system of levers, about 35 pounds of force at the clutch pedal is enough to release the clutch. A relatively great distance and light force at the clutch pedal are changed to a short distance and increased force at the clutch pressure plate.

A typical mechanical linkage assembly is shown in Figure 2-21. The linkage consists of a bellcrank and **actuating rods** which connect the clutch pedal and release lever. The bellcrank pivots on integral ball studs mounted

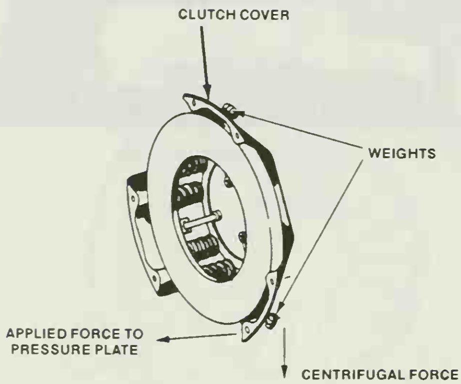


Figure. 2-20. A semi-centrifugal clutch increases application force as engine speed increases. (Ford Motor Company)

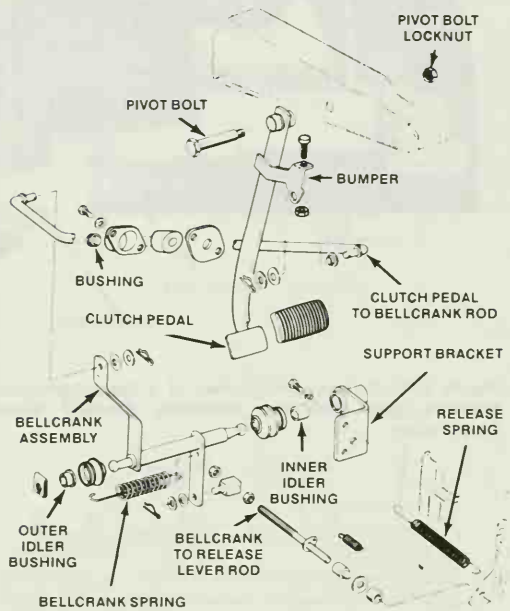


Figure 2-21. A typical mechanical clutch linkage. (American Motors Corporation)

in nylon bushings. A strong over-center spring is used to return the clutch pedal. The return spring also preloads clutch linkage. It compensates for looseness due to wear and keeps the release bearing clear of the spring fingers.

When the clutch pedal is depressed, the bellcrank rod pulls on the bellcrank assembly. The bellcrank moves the release lever rod in a direction to push the release levers. This action releases the clutch. When the pedal is raised, the pressure plate springs and the release springs return the linkage to its original position.

On many vehicles it is difficult to route a number of rods directly to the clutch because of distance or obstructions. In these cases a clutch cable may be used. The cable is a large, wound, multiple-wire unit that operates in a greased housing. Movement of the clutch pedal is transferred to the release fork through the clutch cable. A typical clutch cable is shown in Figure 2-22.

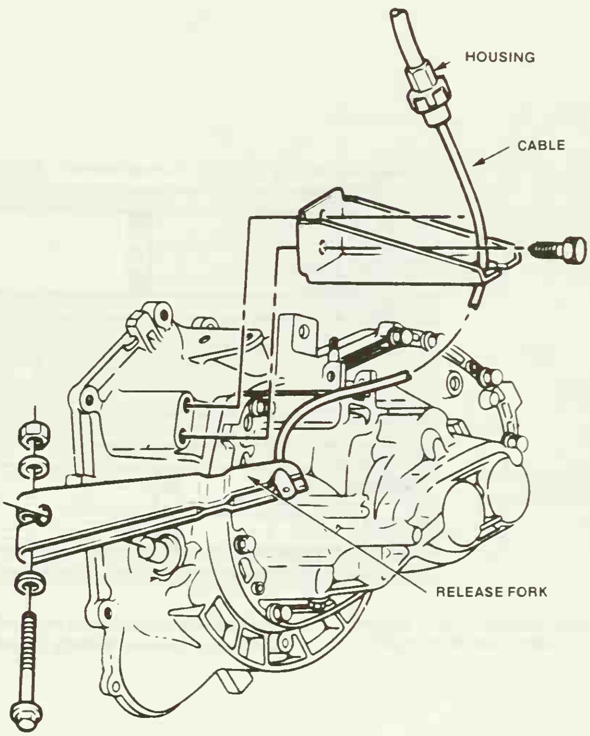


Figure 2-22. The clutch pedal movement may be transferred through a cable to the release mechanism. (Chevrolet Motor Division of General Motors Corporation)

HYDRAULIC CLUTCH LINKAGE

Problems of routing a mechanical linkage from the clutch pedal to the pressure plate assembly led to the development of a **hydraulic clutch linkage.** The hydraulic clutch linkage uses the principles of hydraulics to apply the clutch.

Hydraulic devices work because liquids resist compression. If a cork were forced into a bottle completely full of water, eventually the cork would stop moving. If the cork were forced to move farther, the bottle would break. This characteristic of fluids resisting compression allows them to transmit motion and pressure.

Since liquids are not compressible, they may be used to transmit motion as shown in Figure 2-23. If a cylinder contains two pistons separated by a liquid, pushing on piston **A** will cause movement at piston **B.** Because piston **A** starts the movement, it is called the **apply piston.** Piston **B** is called the **output piston.** If the apply piston is moved eight inches, the output piston will also move eight inches. This demonstrates that motion may be transmitted by a liquid.

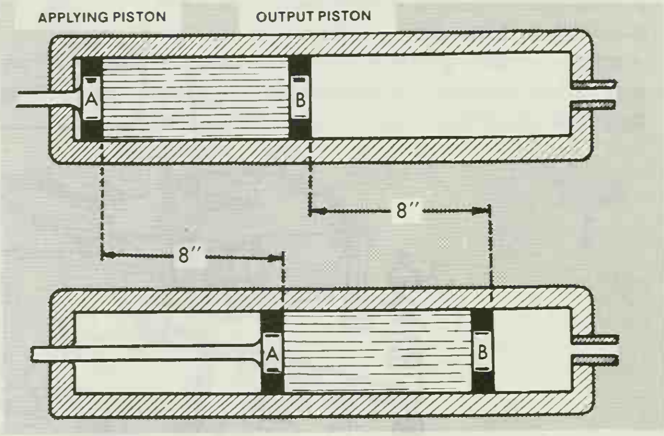


Figure 2-23. Liquids can transmit motion. (Chevrolet Motor Division of General Motors Corporation)

The same principle may be used to transmit motion from one cylinder to another. In Figure 2-24, two cylinders are connected by a tube. When the apply piston in cylinder **A** is moved four inches, the output piston in cylinder **B** also moves four inches. This principle is used in hydraulic clutch linkage.

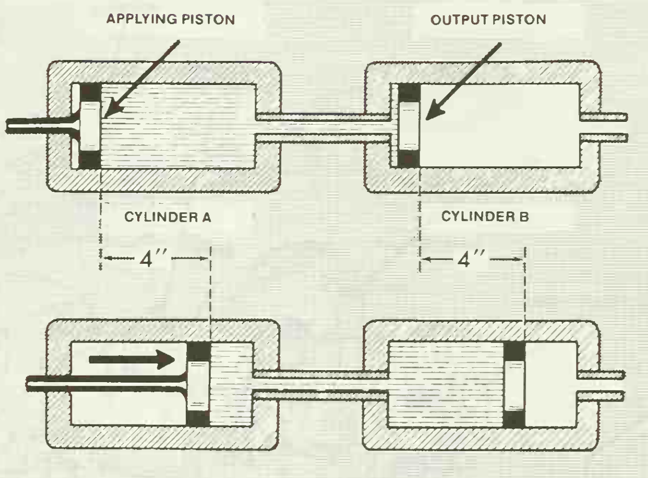


Figure 2-24. Liquids transmit motion between cylinders. (Chevrolet Motor Division of General Motors Corporation)

A hydraulic clutch linkage is essentially two cylinders connected by a pipe. A hydraulic clutch system is shown in Figure 2-25. The mechanism consists of a **remote reservoir**, clutch cylinder, and **slave cylinder**. The reservoir and clutch cylinder are mounted on the dash panel. The slave cylinder is mounted on the clutch housing. The clutch cylinder is operated directly off the clutch pedal.

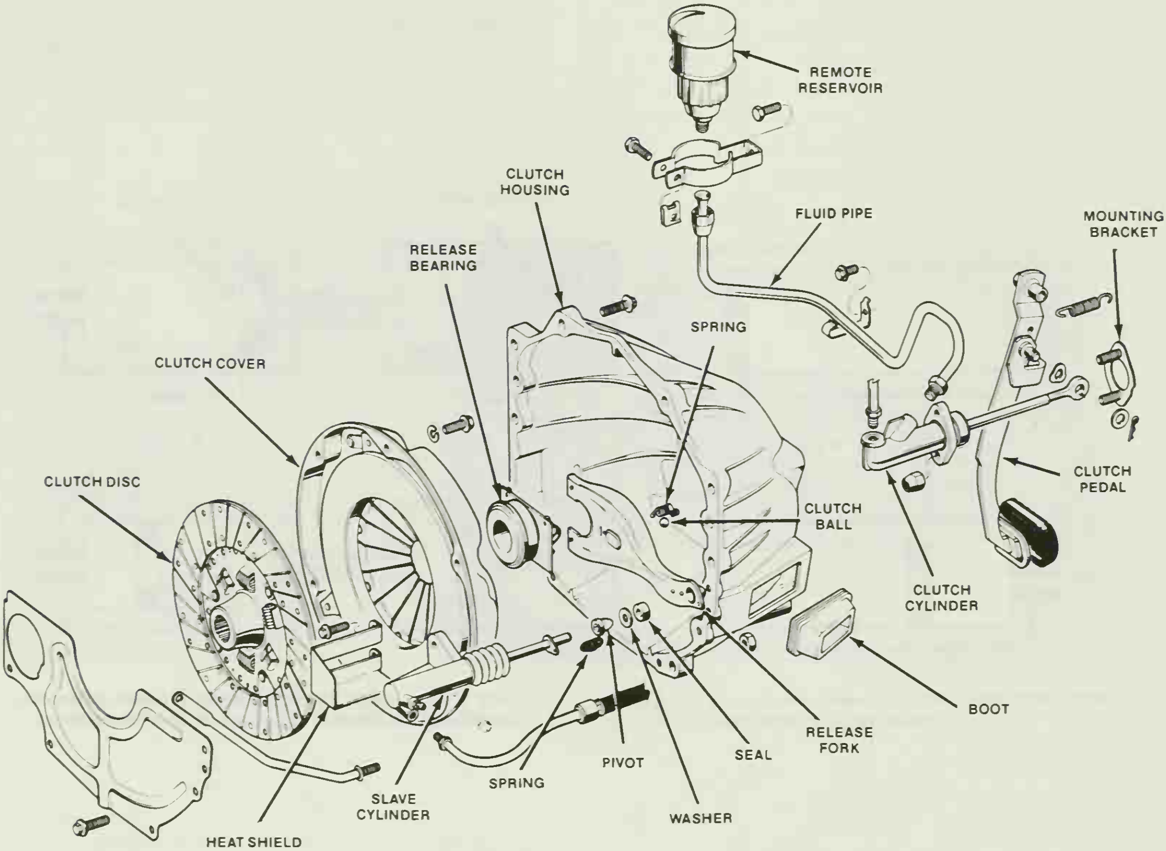


Figure 2-25. Parts of a hydraulic clutch linkage. (American Motors Corporation)

The clutch cylinder is made up of a reservoir for brake fluid and a piston in a cylinder. A hole in the bottom of the reservoir allows brake fluid to fill the area in front of the piston. When the clutch pedal is pushed, the piston is pushed forward in the cylinder. As the piston covers the hole, the fluid is trapped and forced out through a line at the back of the cylinder. An exploded view of the clutch pedal cylinder is shown in Figure 2-26.

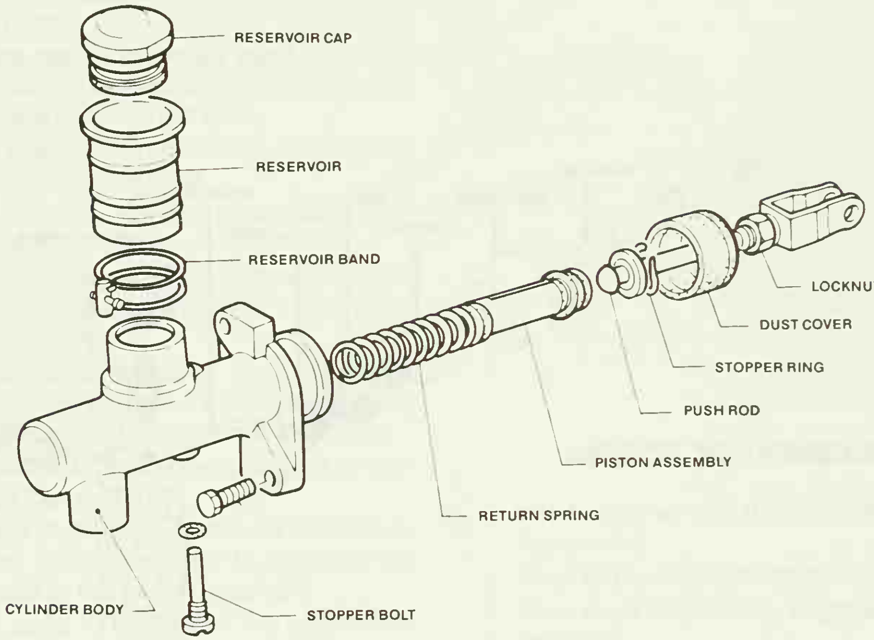


Figure 2-26. Exploded view of a clutch pedal cylinder. (Nissan Motor Corporation in USA)

The fluid is then directed through a line to the slave cylinder. Since it resists compression, it can be used like a mechanical linkage to transmit motion from one place to another.

When fluid enters the slave cylinder it pushes on a piston. The piston moves outward, pushing on a push rod. The push rod moves the clutch release fork. Figure 2-27 shows an exploded view of a slave cylinder.

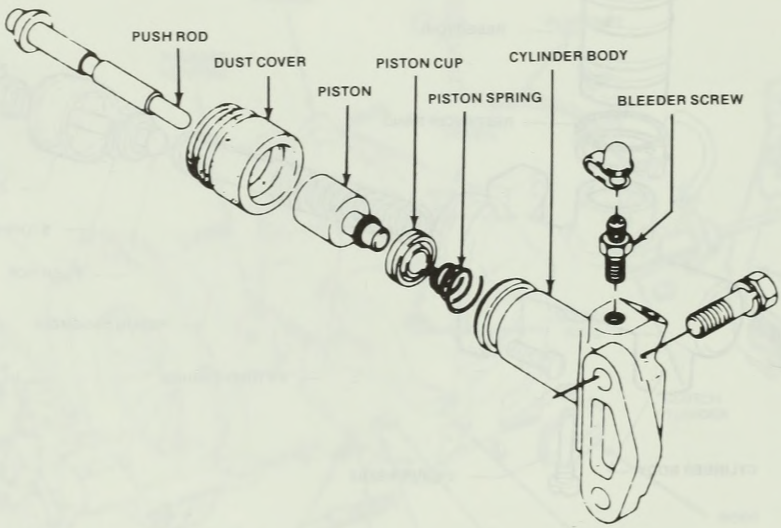


Figure 2-27. Exploded view of a slave cylinder. (Nissan Motor Corporation in USA)

NEW TERMS

Actuating rod Long, round metal rod used to transfer mechanical motion.

Clutch disc Driven member of clutch assembly splined to the transmission input shaft.

Clutch cover Part of the pressure plate assembly bolted to the flywheel.

Clutch fork Unit used to connect the clutch linkage to the release bearing.

Clutch linkage Rods, cables, or hydraulic lines used to actuate the clutch.

Coil-spring pressure plate Pressure plate assembly that uses coil springs to engage the clutch disc.

Diaphragm-spring pressure plate A pressure plate that uses a diaphragm or Belleville spring to push against the disc.

Dry-disc clutch Clutch in the driven disc does not operate in a fluid.

Facings Friction material attached to both sides of the clutch disc.

Flywheel A large wheel driven by the engine and used as a frictional and driving part of the clutch.

Hydraulic clutch linkage Clutch linkage using hydraulic fluid to transfer movement at the clutch pedal to the clutch assembly.

Manual clutch Clutch operated by a driver-controlled foot pedal.

Mechanical clutch linkage A series of rods, bellcranks, or cables used to connect the clutch pedal to the clutch assembly.

Pressure plate The part of the clutch that pushes the clutch disc against the flywheel.

Pilot bushing A bushing or bearing used to support the transmission input shaft in the flywheel or crankshaft.

Release bearing A bearing and sleeve assembly used to push against the pressure plate release mechanism to disengage the clutch.

Release fork Same as clutch fork.

Remote reservoir Reservoir mounted away from a hydraulic cylinder.

Release levers Levers on the pressure plate assembly, used to remove spring pressure from the clutch disc.

Single dry-disc clutch Type of manual clutch that uses one dry clutch disc.

Semi-centrifugal clutch Type of clutch that uses weighted release levers that increase clutch holding force at high engine speed.

Slave cylinder Hydraulic device used to move the clutch release bearing.

Torsion springs Springs in the hub of the clutch disc that absorb torsional vibration.

CHECK YOURSELF

1. What are the two driving members of the clutch?
2. What is the driven member of the clutch?
3. How does the clutch engage and disengage?
4. What is the clutch disc splined to?
5. Why are torsion springs used in the clutch hub?
6. What is the purpose of the release bearing?
7. What do the coil springs in a pressure plate assembly do?
8. How is spring pressure removed from a pressure plate to disengage the clutch?
9. Why does a diaphragm-spring clutch not require release levers?
10. What are the main parts of a hydraulic clutch linkage?

CERTIFICATION PRACTICE

1. Which of the following are components of the manual clutch:
   a. Clutch disc
   b. Pressure plate
   c. Flywheel
   d. All the above
2. When the clutch is disengaged, Mechanic A says the release bearing is moved against the release levers.
   Mechanic B says the pressure plate springs are compressed.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
3. Mechanic A says the clutch disc is driven when the clutch is engaged.
   Mechanic B says the clutch disc is driven when the clutch is disengaged.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
4. Clutch chatter is prevented by:
   a. Cushion springs
   b. Torsion springs
   c. Pressure plate springs
   d. None of the above
5. With hydraulic clutch linkage, the clutch-fork and release-bearing assembly are moved with:
   a. Slave cylinder
   b. Clutch pedal cylinder
   c. Bellcrank
   d. None of the above

ANSWERS

1. d, 2. c, 3. a, 4. a, 5. a

DISCUSSION TOPICS AND ACTIVITIES

1. Depress the release levers of a coil-spring pressure plate assembly. What happens to the pressure plate?
2. Depress the center of a diaphragm in a diaphragm-spring pressure plate. What happens to the pressure plate?

Unit 3

Manual Clutch Service

The manual clutch is one of the most severely stressed components in the automotive power train. Heat and friction are developed each time the clutch is engaged or disengaged. If the driver uses the clutch with care, the components may last many thousands of miles. If the clutch is abused or used in hilly areas or with heavy loads, its service life is shortened. In this unit we will present the preventive maintenance, troubleshooting and service procedures common to manual clutches.

Preventive Maintenance

Troubleshooting

Service

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

3-1 Lubricate clutch linkage.
3-2 Adjust clutch pedal free play.

3-3 Perform a clutch road test and noise diagnosis.

3-4 Remove a clutch.
3-5 Clean and inspect clutch components.
3-6 Check clutch housing for misalignment.
3-7 Replace a clutch release bearing.
3-8 Install a new pilot bearing.
3-9 Install the clutch.
3-10 Service the clutch and slave cylinder.
3-11 Bleed a hydraulic clutch system.

JOB COMPETENCY 3-1
LUBRICATE CLUTCH LINKAGE

The suspended-type clutch pedal is connected to the outer lever of the bellcrank assembly by the clutch-pedal-to-bellcrank rod. The inner lever of the bellcrank assembly is connected to the release lever by the bellcrank-to-release-lever rod. The bellcrank assembly pivots on the two ball studs attached to the inner and outer ends of the bellcrank assembly. The **ball studs** pivot in nylon idler bushings.

The clutch bellcrank assembly has a ball stud at each end. The ball studs pivot in nylon idler bushings which are pre-lubricated at time of assembly.

The bellcrank ball studs, idler bushings, release lever pivot ball, and clutch pedal pivot bolt and bushings require periodic lubrication.

To lubricate the ball studs and idler bushings, you must remove the bellcrank. The release lever pivot ball is accessible through the lever opening in the clutch housing. The clutch pedal and linkage components should be lubricated with chassis lubricant or engine oil at the intervals specified in the manufacturer's service manual. Points requiring lubrication are shown in Figure 3-1.

In a **cable-operated clutch linkage** the cable must be removed from its housing, greased, and replaced. Some cable units have a grease fitting so they may be greased without disassembly.

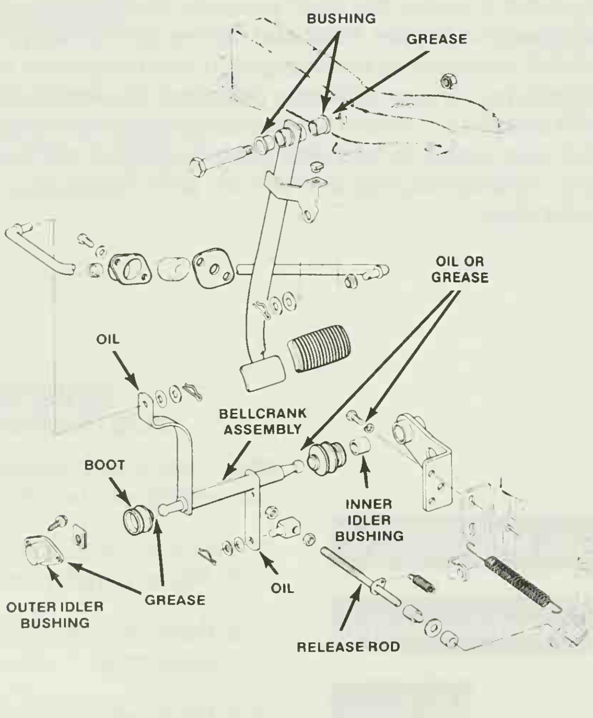


Figure 3-1. Points where the clutch linkage is lubricated. (American Motors Corporation)

JOB COMPETENCY 3-2 ADJUST CLUTCH PEDAL FREE PLAY

A clutch pedal **free play** adjustment is necessary whenever the clutch does not disengage or engage properly, or when new clutch parts are installed. Improper adjustment of the clutch pedal free play is often one of the causes of clutch failure and can be a factor in causing some transmission failures.

To check and adjust the pedal free play, measure the distance from the floor pan to the top of the pedal as shown in Figure 3-2. This measurement is called **pedal height.** If this distance is not correct according to specifications, you will have to adjust the pedal stop bolt. This bolt acts as a stop on the pedal; making it longer or shorter will change pedal height.

Clutch pedal free play is the distance the clutch pedal moves before the release bearing contacts the pressure plate release levers or diaphragm spring. To determine the free play, push the pedal slowly until the clutch release fingers contact the clutch release bearing as shown in Figure 3-3. Note the measurement. The difference between the reading with the pedal in the depressed position and the reading with the pedal in the fully released position is the pedal free play. Free play prevents the clutch slippage that would occur if the bearing were held against the fingers, and prevents the bearing from running continually. A clutch that has been slipping before may still slip after the adjustment because of previous heat damage.

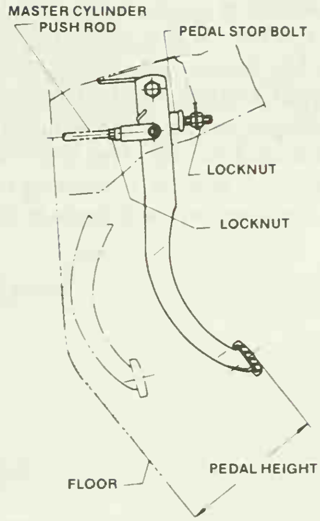


Figure 3-2. Pedal height is the distance from the floor to the pedal adjusted with a stop bolt. (Nissan Motor Corporation in USA)

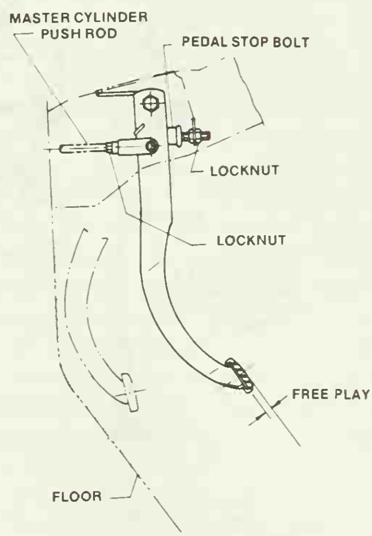


Figure 3-3. The distance the pedal moves before the release bearing contacts the release levers is called free play. (Nissan Motor Corporation in USA)

The free play measurement is compared to specifications found in the manufacturer's service manual. If the measurement is too large or too small, the clutch linkage must be adjusted. Usually the fork rod connected to the release fork is threaded and has a nut that contacts a swivel. The fork rod can be made longer or shorter by turning the nut. An adjuster is shown on the linkage in Figure 3-4.

The adjustment is made by loosening the nut and moving it up or down the rod as required. Some adjusters must be disconnected from the linkage before they can be adjusted. Check that the adjustment is correct by measuring the free play as explained earlier.

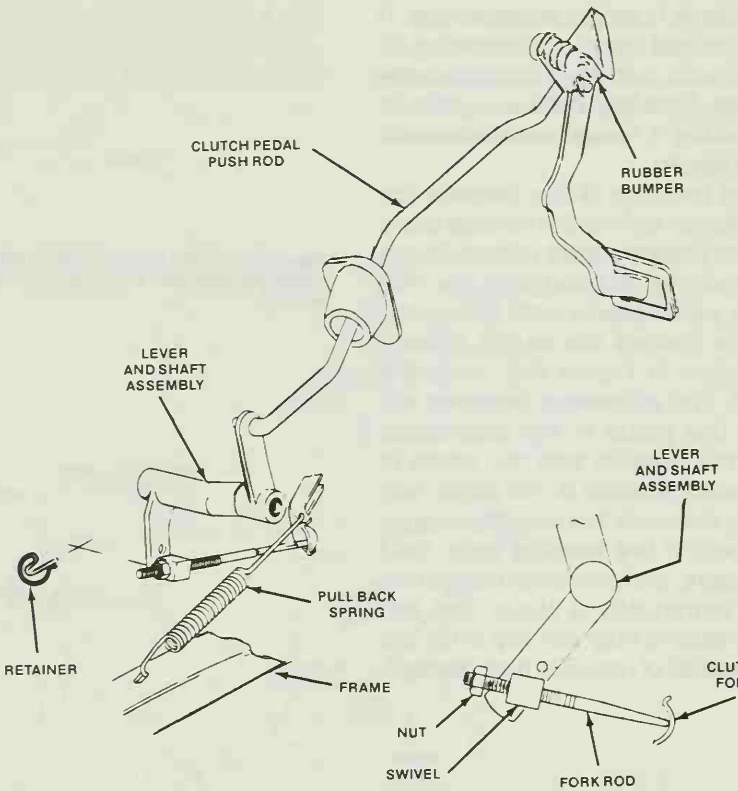


Figure 3-4. Pedal free play may be adjusted by adjusting the fork rod used to push on the release bearing fork. (Buick Motor Division of General Motors Corporation)

Cable-operated clutch linkage is often adjusted by lengthening or shortening the clutch cable housing. The cable assembly is equipped with an adjusting nut which fits on threads on the outside of the clutch cable housing. These parts, shown in Figure 3-5, are often mounted where the clutch cable pushes through the engine compartment. To adjust the cable, pull on the clutch cable housing with one hand and turn the adjusting nut with the other hand as shown in Figure 3-6. After an adjustment, measure the free play.

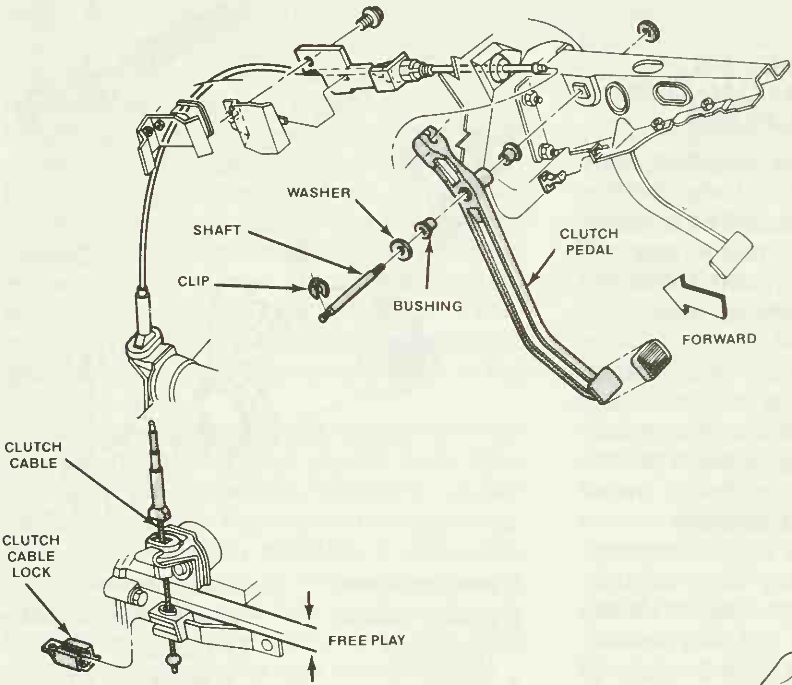


Figure 3-5. Adjustment parts for a cable-operated clutch. (Chrysler Corporation)

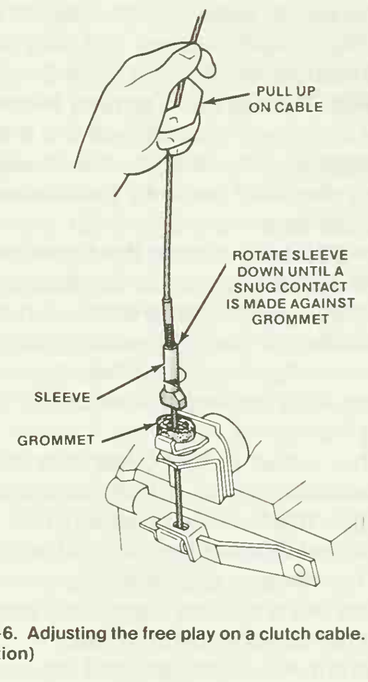


Figure 3-6. Adjusting the free play on a clutch cable. (Chrysler Corporation)

A hydraulic clutch linkage may also require a pedal free play adjustment. Typically the rod from the slave cylinder to the clutch fork is adjustable as shown in Figure 3-7. This rod is lengthened or shortened by moving the adjusting nut back or forth along its threads. After an adjustment, always recheck pedal free play.

JOB COMPETENCY 3-3 PERFORM A CLUTCH ROAD TEST AND NOISE DIAGNOSIS

To diagnose a clutch-related complaint, test-drive the vehicle. Pick a quiet road with a smooth surface so that noises will be evident. If possible, use a road with hills where the clutch must work especially hard. Drive the vehicle long enough to warm up the clutch to operating temperature. Stop the vehicle frequently and drive away, shifting through each of the gears. If possible use the clutch on a hill. During the test drive look for these conditions: whirring noise, gear clash, clunks or knocks, squeaks, grinding noise, **pedal pulsation,** vibration, **chatter, slippage.**

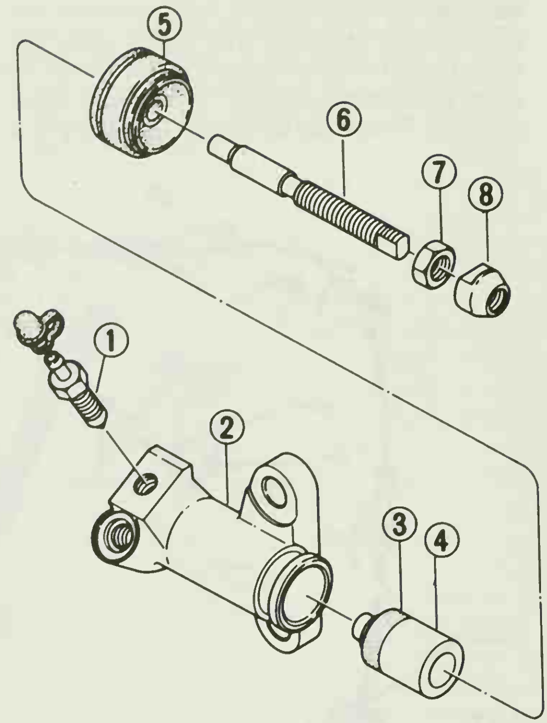
A whirring, light grinding, heavy grinding, and snapping when free play is removed or when the clutch pedal is depressed is almost surely the release bearing. The bearing may have failed internally, or it may be turning on the hub. If it has been turning on the hub, be sure to inspect the hub and the pressure plate fingers or levers. In either case, the transmission will have to be removed to replace the bearing and/or hub.

When a noise similar to the above occurs, but with the transmission in gear and the clutch disengaged, the trouble can be the pilot bearing in the flywheel. In this case, the transmission input shaft has stopped, but the flywheel is turning, thus making the pilot bearing work.

Another noise in this class may be from the transmission gears. The noise should stop when the clutch is disengaged. The clutch may not disengage if the facing is warped or torn, if the linkage or pressure plate adjustments are worn, of if the clutch disc is sticking to the flywheel or pressure plate.

Still another possibility is the sound of the clutch disc rivets or steel portion of the clutch disc wearing against the flywheel or pressure plate. A ceramic-faced clutch is also noisier than a molded or woven-faced one.

Gear clash is sometimes the fault of the clutch if the clutch is not disengaging. To check this, start the engine and very carefully start the shift lever toward first gear until the gears just begin to touch each other, hold this position and slowly depress the clutch. When the clutch pedal is approximately one inch from the floor, the gears should stop grating and a quiet shift should be possible. Noise from grating gears when the vehicle is moving is usually due to transmission problems or driver technique.



1. BLEEDER SCREW
2. SLAVE CYLINDER
3. PISTON CUP
4. PISTON
5. DUST COVER
6. ADJUSTABLE PUSH ROD
7. LOCKNUT
8. ADJUSTING NUT

Figure 3-7. The hydraulic clutch linkage may be adjusted at the slave cylinder. (Nissan Motor Corporation in USA)

Clunks or knocks are caused by large pieces of metal contacting one another rapidly. This means that some parts are not secure, are worn, or are loose. A small clunk is normal due to drive line clearances.

If the clunk or knock is a single one when engaging or disengaging the clutch, it may be the linkage passing a high-resistance point, or it may be interference with an adjacent component. A worn crankshaft thrust bearing will clunk when the clutch is rapidly disengaged. A steady clunking or knocking noise can usually be changed by engaging or disengaging the clutch. One or two out-of-adjustment release fingers will cause a knocking noise when the release bearing first contacts them. Steady knocking in the clutch area can be a loose flywheel or pressure plate, a bad engine or transmission bearing, a broken transmission gear, or loose parts bouncing around in the clutch housing.

Squeaks of various types may be encountered in the clutch area. Again, determine when the squeak occurs. When the squeak can be heard with the engine not operating, then a non-rotating problem is indicated. The obvious places to check are linkage, release-bearing hub and guide, release-bearing lever friction points, pressure plate release-lever-bearing, and friction points.

If the squeak can be heard only when the engine is operating, then the source of the noise is a rotating item. With the clutch disengaged, the squeak can be the release bearing, the fingers on the bearing if the bearing will not rotate, the pilot bearing if the transmission is in gear, or the release levers rubbing on the pressure plate cover windows.

A squeak when the clutch is engaged is a rotating situation that also includes the transmission input shaft and eliminates the release bearing (if the linkage is properly adjusted) as a possible noise source. Since the input shaft is rotating, the transmission front bearing and countergear are also rotating. The pilot bearing can be eliminated because the flywheel and the input shaft are rotating at the same speed. A badly worn clutch facing can cause a squeal if the lining rivets or metal part of the clutch disc contacts the flywheel or pressure plate.

Grinding noises are caused by metal-to-metal contact that is not separated by lubricant. By the time the noise has developed to a grind, the parts involved are usually damaged. The same noise occurrence with the engine operating or not operating is probably in the linkage. The most common sources of grinding noises in the clutch area are the release bearing, pilot bearing, or transmission. A badly worn facing can cause a grind, but only with the transmission in gear and the clutch engaged with the engine operating.

Clutch pedal pulsation is a rapid up-and-down (pumping-type) movement of the pedal without any noise. This pedal movement, which is slight, can be felt by the driver. However, on occasion, pedal movement will be great enough to be seen and cause a noticeable vibration.

Clutch pedal pulsation occurs when the release bearing first makes contact with the clutch cover release levers (clutch partially disengaged) or at any time the release bearing is in contact with the release levers. Pulsation is usually caused by incorrect clutch release lever height or clutch housing misalignment. Check clutch operation as follows: start the engine, slowly depress the clutch pedal until the release bearing first makes contact with the clutch release levers, and check for pulsation. Continue to depress the clutch pedal while checking for pulsation until the pedal is fully depressed.

Clutch-related vibrations are different from pedal pulsations. They can be felt throughout the vehicle. Clutch vibrations usually occur at a relatively high engine speed (over 1500 rpm) regardless of clutch pedal position. Clutch and engine vibrations are sometimes difficult to separate. If the vibration disappears when the clutch is disengaged, then the trouble is probably in the clutch disc. An out-of-balance pressure plate or flywheel can cause a vibration.

A symptom similar to the vibration can exist if the transmission is out of alignment with respect to the engine or clutch housing, or if the release bearing is cocked. This is caused by the clutch pressure plate release fingers alternately pushing the release bearing and bearing lever. The motion is transferred through the clutch linkage to the

pedal. At high engine speeds, this motion is like a vibration.

Clutch chatter can be described as shaking or shuddering that is felt throughout the automobile. Chatter usually develops when the clutch cover pressure plate first makes contact with the clutch disc and stops when the clutch is fully engaged (clutch pedal released). Chatter is usually caused by oil or grease on the facings or broken cushion springs in the clutch disc. The situation is also aggravated by loose or oil-soaked engine or transmission mounts. Other items that can cause chatter are: worn release bearing or lever; warped, grooved, cracked, or broken pressure plate; badly worn facings; or a heat-checked flywheel.

Clutch slippage is a condition in which the engine overspeeds (overrevs) but does not provide any power to the drive wheels. Clutch slippage occurs when the clutch disc is not gripped firmly between the flywheel and clutch cover pressure plate and rotates or slips between them at high torque. Clutch slippage can occur during initial acceleration or during gear shifts.

Oil, grease, or glazed linings and facings can cause slipping because the friction quality of the lining, flywheel, and pressure plate has changed. Worn facings can cause a loss of pressure plate spring preload. Excess heat, usually from slipping, can cause a loss of spring tension and more slipping. Binding of linkage or clutch parts or wrong adjustments can also cause slipping.

When the clutch will not release and linkage adjustment does not help, then the clutch disc hub can be stuck on the transmission input shaft. The splines may be burred, the pressure plate may be broken, the clutch disc may be installed backward, there may be air or no fluid in the hydraulic control, bent forks or release bearing lever could be causing the problem.

To determine where high resistance exists in the clutch or linkage, start by disconnecting the linkage at the release bearing lever or cross shaft, then operate the linkage. If necessary, progressively disconnect more linkage until just the pedal pivot remains. Any binding in the pressure plate that cannot be remedied with lubricant will have to be repaired by removing the clutch. The release bearing hub may be binding on the guide or transmission input shaft bearing retainer.

Chronic wear or breakage of clutch components that cannot be attributed to the driver, misapplication, or overloading, may be due to transmission or clutch **housing misalignment.** Misalignment may also cause hard pedal or hard shifting. The flywheel face and pressure plate mounting surface must be flat and parallel with the engine block clutch housing mounting surface on the clutch housing. If the transmission housing is aligned to the inside diameter of the clutch housing, then the clutch housing inside diameter must be concentric with any diameter of the flywheel.

JOB COMPETENCY 3-4
REMOVING A CLUTCH

In order to remove the clutch the engine must be separated from the transmission. Always follow a detailed manufacturer's service manual when you separate the transaxle or transmission from the engine. **Safety note:** ***Always disconnect the battery ground to prevent accidental engine cranking when working on the clutch.***

In some vehicles the engine may be supported with a bar across the engine compartment as shown in Figure 3-8. With the engine supported, the transaxle is separated from the rear of the engine by removing the transaxle-to-engine attaching bolts as shown in Figure 3-9. The transaxle assembly may then be disconnected and removed from the bottom of the vehicle. With other transaxle arrangements, it is easier to remove the engine to service the clutch.

The first step on front-engine vehicles is to remove the hood. The hinges are marked so they may be reinstalled without readjusting. Then unbolt the hinges. Use rags or fender covers to protect the paint near the hinges as the hood is removed.

The engine coolant and oil must be drained. Open a valve on the bottom radiator tank to drain the coolant. While the coolant and oil are draining continue to prepare the engine for removal. Place fender covers on

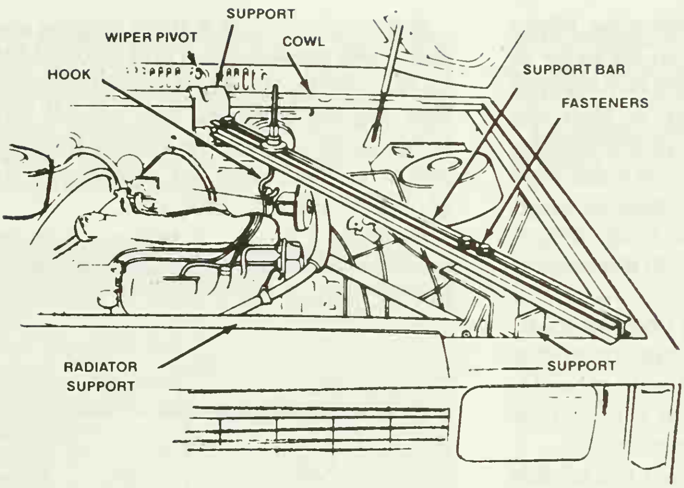


Figure 3-8. In some vehicles the engine is supported and the transaxle is removed from below the vehicle. (Chevrolet Motor Division of General Motors Corporation)

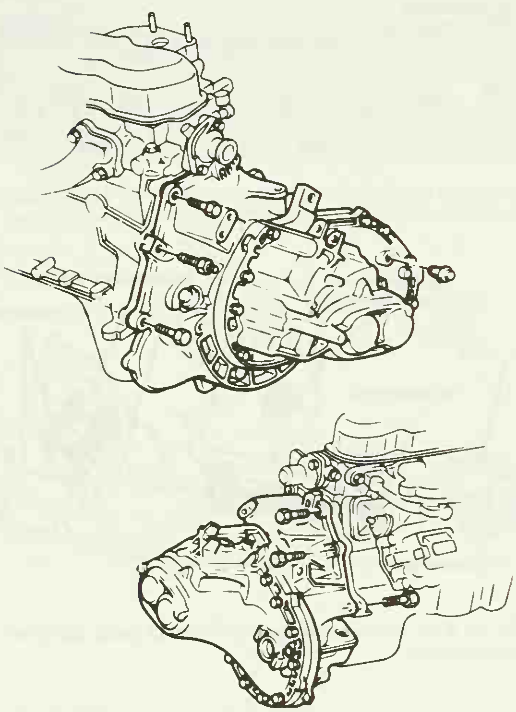


Figure 3-9. In some vehicles the transaxle is separated from the engine and removed from below the vehicle. (Chevrolet Moter Division of General Motors Corporation)

the fenders to protect the paint. Remove the air cleaner. Vehicles with emission-control equipment often have several vacuum lines connected to the air cleaner. Each line should be identified. Wrap masking tape around the lines and the connecting points. A numbered code can then be written on the tape.

Electrical connections to the alternator, ignition, emission-control system, and warning lights must be disconnected. Masking tape should be used to help identify the wires later. Disconnect the battery, and remove it from the vehicle. Put the battery on a trickle charger to prevent it from discharging.

Disconnect the fuel line from the tank to the fuel pump and plug it to prevent fuel leakage. Disconnect the throttle linkage from the carburetor or fuel-injection system.

The radiator must be removed to provide clearance when removing the engine. Disconnect the top and bottom radiator hoses. Remove the mounting bolts and lift out the radiator. Disconnect heater hoses from the engine.

In vehicles with power steering, the power-steering pump must be unbolted from the engine. Place the unit to the side of the engine compartment. This prevents having to disconnect the hydraulic lines. Follow the same procedure with airconditioners. Unbolt the compressor from the engine and set it aside without disconnecting the refrigerant lines. If the lines are disconnected, the system will require recharging.

Attach a pulling cable to the engine. Many engines have hooks or eyes to be used in lifting the engine. Other engines require that the sling be bolted to the engine. Remove a bolt from the front and rear of the engine and reinstall through the sling. The bolts used must be large enough and go deep enough into the engine to support the load. Attach the sling to an engine crane. With the engine supported on the crane, disconnect the engine-to-transaxle attaching bolts. Disconnect the exhaust pipe or pipes from the engine. Unbolt the engine to frame mounts. Carefully lift the engine out of the engine compartment as shown in Figure 3-10.

After engine removal, support the clutch housing of the transaxle as shown in Figure 3-11. This prevents damage to the rubber transaxle mounts.

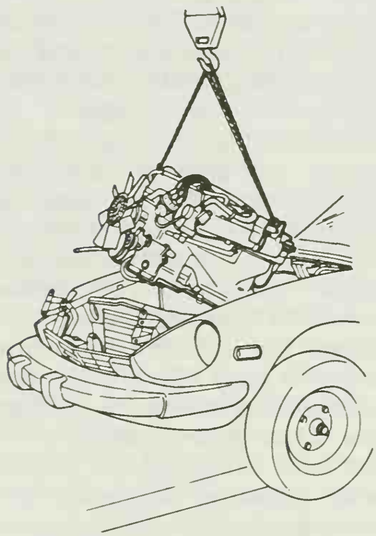


Figure 3-10. The engine must be removed for access to the clutch in some transaxle arrangements. (Nissan Motor Corporation in USA)

If the vehicle has a front engine and rear drive, the transmission and drive shaft must be removed before removing the clutch. On rear-engine vehicles, the engine must be removed to service the clutch. Transmission and drive shaft removal procedures are presented in detail in later units.

Remove the clutch release bearing and the sleeve assembly from the clutch release fork (Figure 3-12). If the old pressure plate

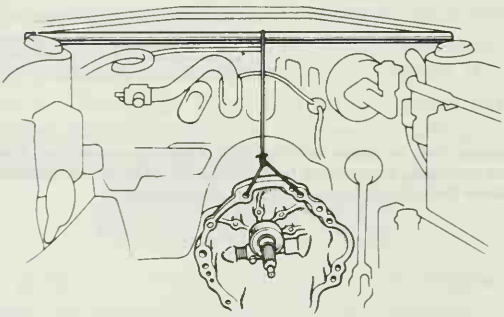


Figure 3-11. After engine removal the clutch housing must be supported.

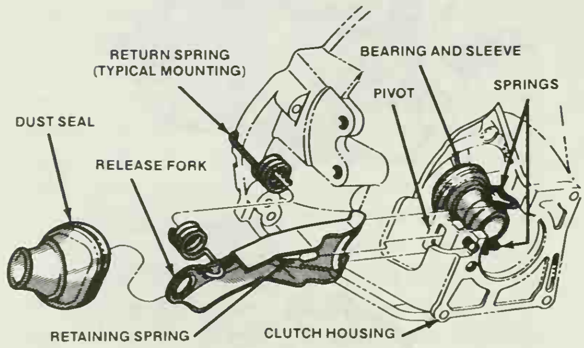


Figure 3-12. Release bearing and related parts. (Chrysler Corporation)

is to be reused, mark the clutch cover and flywheel (Figure 3-13) so that they may be installed in the same place when reinstalling the clutch assembly. This will maintain any factory balancing. Loosen and back off each of the clutch cover attaching bolts, one or two turns at a time, to avoid bending the cover flange. Remove the clutch assembly and disc from the clutch housing (Figure 3-14).

Caution: Handle clutch and disc carefully to avoid contaminating the friction surfaces.

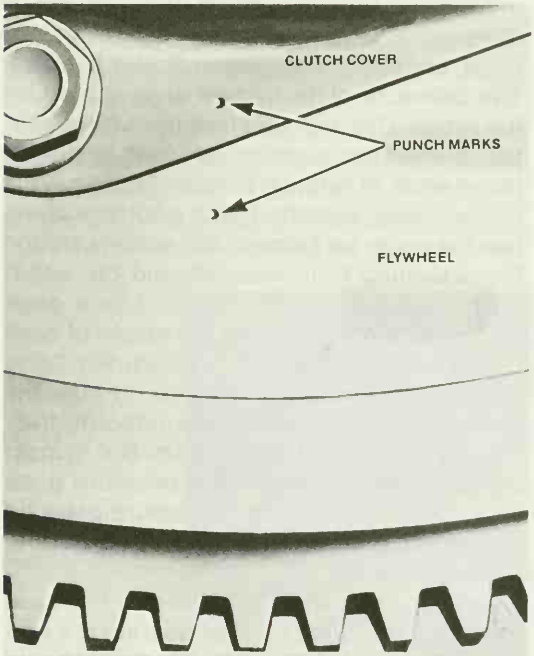


Figure 3-13. The clutch cover and flywheel should be punch-marked as a reference in reassembly. (Chrysler Corporation)

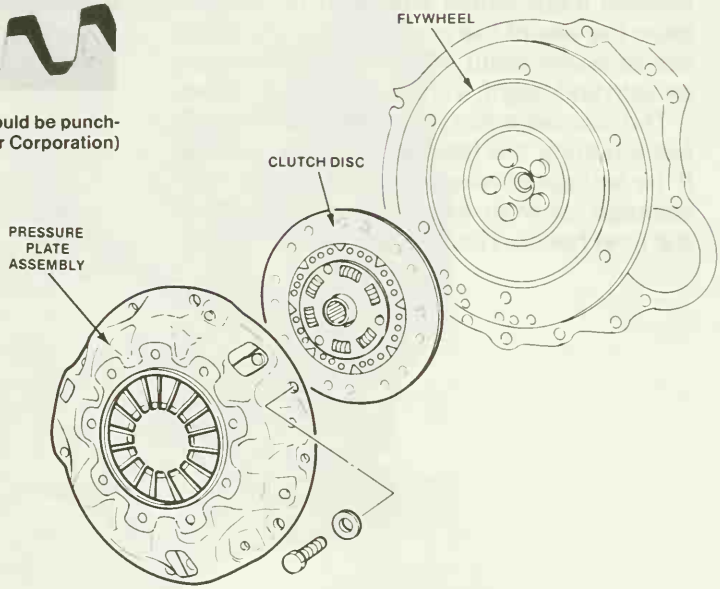


Figure 3-14. After removing the clutch cover bolts, remove the pressure plate and disc. (Nissan Motor Corporation in USA)

JOB COMPETENCY 3-5 CLEAN AND INSPECT CLUTCH COMPONENTS

Clean the dust out of the clutch housing with a rag. Inspect for oil leakage through engine rear main bearing oil seal and transaxle input shaft seal. If leakage is noted, it should be corrected at this time. **Safety note:** ***There may be asbestos in clutch disc dust. Do not blow dust into the air with compressed air as it is dangerous to breathe.***

The friction face of the flywheel should have a uniform appearance throughout the entire disc contact area. If there is heavy contact on one part of the wear circle and a very light contact 180 degrees from that part, the flywheel may be sprung or improperly mounted. The friction face of the flywheel should also be free from discoloration, burned areas, small heat cracks, grooves, or ridges. If any of these conditions is noted, the flywheel must be removed and resurfaced or replaced.

The pilot bushing or bearing pressed in the rear end of the crankshaft should be smooth and show no excessive wear. A new transmission input clutch shaft can be used to gage the size of the bushing. The end of the transmission input clutch shaft should be smooth and bright, without grooves or ridges.

The disc assembly should be handled without touching the facings. Replace the disc if the facings show evidence of grease or oil soakage, or wear to less than .015 inch of the rivet heads. The hub splines and splines on the transmission input clutch shaft should fit snugly without signs of excessive wear. Metallic parts of the disc assembly should be dry and clean and show no evidence of having been hot. Each of the arched springs between facings should be unbroken, and all rivets should be tight.

Wipe the friction surface of the pressure plate with a suitable solvent. Using a straight edge, check the pressure plate for flatness. The pressure plate friction area should be flat within .015 inch and free from discoloration, burned areas, cracks, grooves, or ridges. Inner ends of release levers should have a uniform wear pattern. Using a surface plate, test the cover for flatness. All sections around the attaching bolt holes should be within .015 inch of the surface plate. Use a gage (Figure 3-15) for checking the height of each of the release levers. This is usually done with the pressure plate mounted to the flywheel. If the fingers are not uniform, they may be adjusted on some units. But in most cases you must replace the pressure plate assembly. If the disc and pressure plate do not meet specifications outlined above, replace them.

Examine the condition of the clutch release bearing. The clutch release bearing is a prelubricated, sealed thrust bearing and should not be soaked in solvent. When held in the hands under a light thrust load, the bearing should turn freely, with no evidence of roughness. If the bearing is noisy, rough, or dry, install a new one on the sleeve as explained later.

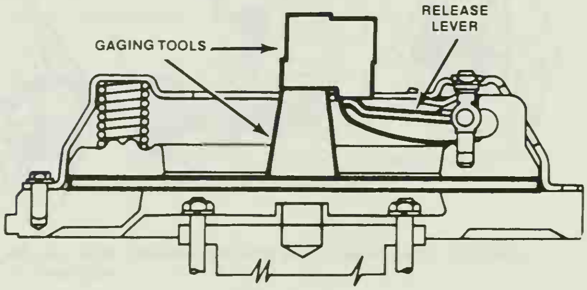


Figure 3-15. Gaging tools may be used to measure release lever height. (American Motors Corporation)

JOB COMPETENCY 3-6
CHECK CLUTCH HOUSING FOR MISALIGNMENT

A misaligned clutch housing can cause improper clutch release, driven plate failure, front transmission bearing failure, uneven wear in the crankshaft pilot bushing and clutch shaft roller bearings, clutch cackle noise, and in extreme cases vibration and jumping out of gear on deceleration or acceleration.

To check for a misaligned housing, use a bolt and nut to support a dial indicator. Install a nut on a bolt with 10 or 12 threads exposed and install the bolt into the crankshaft. Tighten the nut to secure the bolt in the flywheel. Install the clutch housing on the engine and tighten bolts to the specified torque.

Install the dial indicator on the bolt. Position the stylus so that it touches the rear face of the clutch housing approximately ⅛ inch from the edge of the rear opening, as shown in Figure 3-16. Check the squareness of the face of the housing by turning the crankshaft. The total indicator reading should not exceed 0.010 inch. Crankshaft end play must be held to zero (0.000 inch) when checking face alignment, by prying the crankshaft forward or rearward with a pry bar. Alignment of the clutch housing may be corrected by installing shims between the engine and the clutch housing.

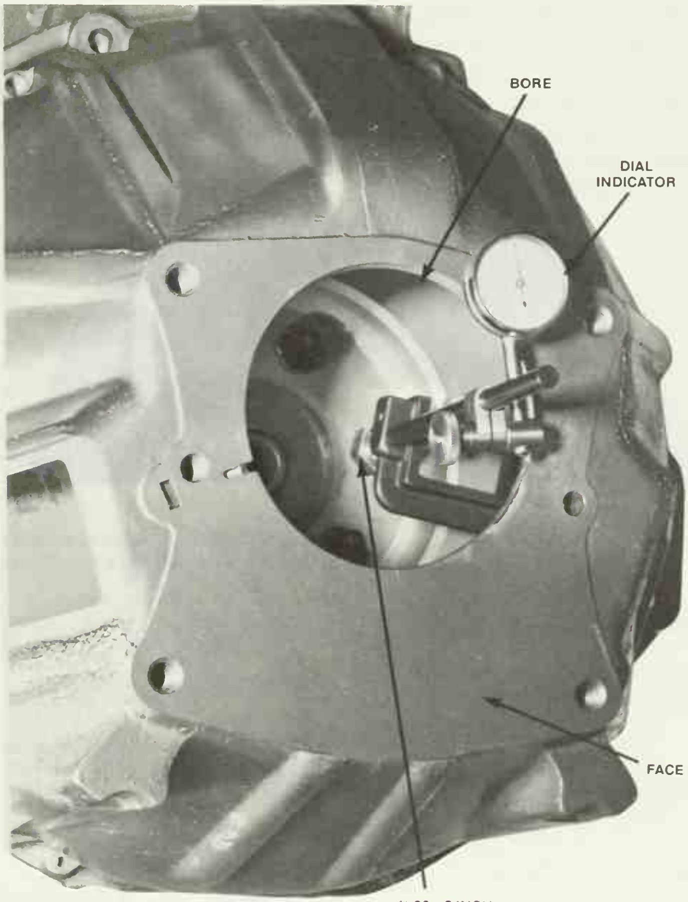


Figure 3-16. Checking runout with a dial indicator. (American Motors Corporation)

JOB COMPETENCY 3-7 REPLACE A CLUTCH RELEASE BEARING

The release bearing is retained on a hub or sleeve with a press fit. Remove the old release bearing and install a new release bearing on the hub or sleeve. Support the bearing and sleeve in a vise or press and carefully press out the sleeve.

Clean the sleeve in solvent and remove all old lubricant. Be careful when installing a new clutch release bearing to avoid damaging the bearing race. Never drive the bearing on the sleeve with a hammer. Place the new bearing on the sleeve and place the old bearing against the face of the new bearing. Support the parts in a vise and carefully press the new bearing on the sleeve as shown in Figure 3-17. Make sure the bearing is seated on the shoulder of the bearing sleeve. Rotate bearings as they are pressed together.

Install the release bearing on the release bearing fork. Lubricate points of movement with high temperature lubricant.

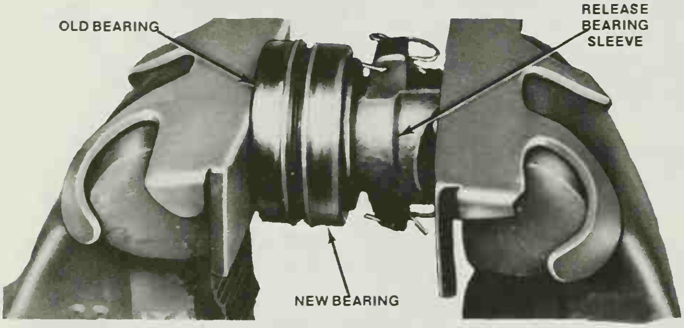


Figure 3-17. A new release bearing is pressed on the sleeve using the old bearing and a vise. (Chrysler Corporation)

JOB COMPETENCY 3-8
INSTALL A NEW PILOT BEARING

A worn or damaged pilot bearing must be replaced, or the transmission input shaft will not be properly supported. This can result in poor clutch operation and rapid wear.

Remove the pilot bearing with a special puller. The puller is installed into the pilot bearing as shown in Figure 3-18. Tightening the nut with a wrench tightens the puller in the pilot bearing and pulls it out. Drive the new bearing into position with the correct driver. Lubricate the bearing with recommended high temperature lubricant.

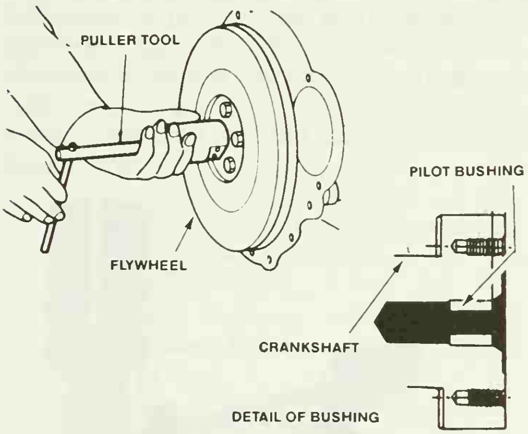


Figure 3-18. A puller is used to remove the pilot bearing. (Buick Motor Division of General Motors Corporation)

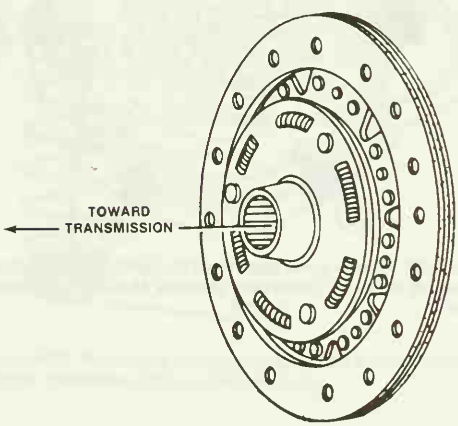


Figure 3-19. The long part of the clutch hub assembly usually points toward the transmission. (Nissan Motor Corporation in USA)

JOB COMPETENCY 3-9
INSTALL THE CLUTCH

Try the clutch disc on the transmission input shaft for proper fit before installation. Be sure the long hub on the clutch disc faces in the correct direction as shown in Figure 3-19. Many discs have the words "flywheel side" as an aid to proper installation. If in doubt, check the correct service manual.

The clutch disc must be installed on center with the pilot bearing so that the transaxle or transmission input shaft will go through the center of the hub splines and into the pilot bearing. To ensure this alignment use a **clutch disc alignment tool** to install the disc and pressure plate. This tool fits into the pilot bearing and supports the clutch disc on center while the pressure plate assembly is bolted down. A typical alignment tool is shown in Figure 3-20. This tool has a set of splines to hold the disc. If an alignment tool is not available, use a spare transmission clutch shaft to align the driven plate.

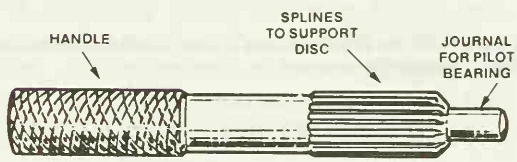


Figure 3-20. A clutch disc alignment tool. (Buick Motor Division of General Motors Corporation)

Install the alignment tool in the pilot bearing, and install and center the disc against the flywheel as shown in Figure 3-21.

Position the pressure plate assembly over the clutch disc. Line up any assembly marks made during disassembly. Start all the clutch cover bolts by hand (Figure 3-22). Tighten the clutch cover bolts alternately and evenly to specifications with a torque wrench. If the clutch cover bolts are not properly tightened, the cover may be distorted.

Install the engine transaxle or transmission, following the reverse of the disassembly procedure. Test-drive the vehicle to check for proper clutch operation.

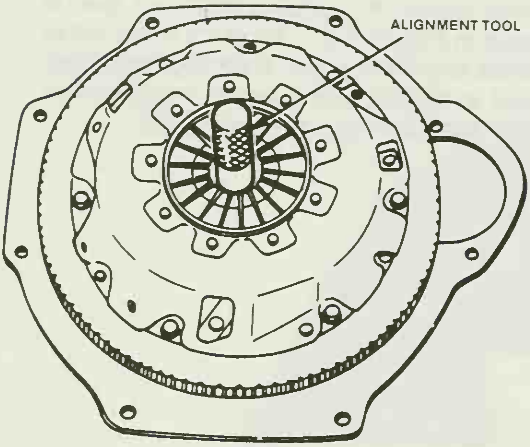


Figure 3-21. An alignment tool is used to center the clutch disc. (Chrysler Corporation)

JOB COMPETENCY 3-10 SERVICE THE CLUTCH AND SLAVE CYLINDER

As described earlier, improper clutch operation may be caused by a worn clutch or slave cylinder in a hydraulic linkage system. If this is the case, these units will require overhaul or replacement.

In order to remove the clutch cylinder for service, remove the master cylinder and the power brake unit as an assembly. Disconnect hydraulic lines at the cylinder. Disconnect the cylinder push rod from the clutch pedal. Remove nuts attaching the cylinder to the dash panel and the mounting bracket and remove the clutch cylinder.

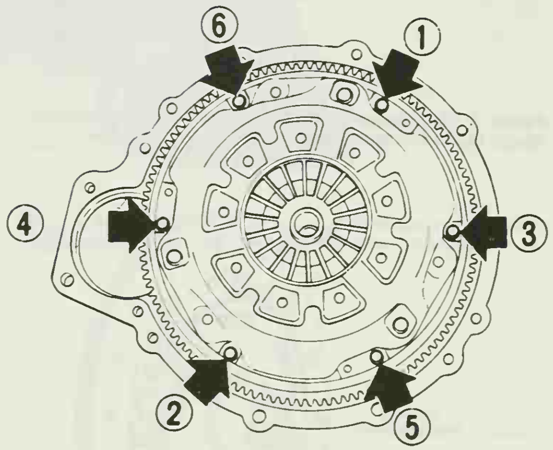


Figure 3-22. Clutch cover bolts must be tightened alternately and evenly to avoid distortion. (Nissan Motor Corporation in USA)

To service the cylinder, clean the exterior of the cylinder thoroughly. Remove the boot. Remove the push rod snap ring and remove the push rod, seal, and washer. Remove the plunger and spring assembly from the cylinder. Tap the cylinder on a block of wood to dislodge the assembly. Compress the spring slightly and pry the tab of the valve stem retainer, spring and valve stem from the plunger as shown in Figure 3-23.

Remove the spring, valve stem, spring retainers, and wave washer from the plunger. Remove the seal from the plunger. Clean the parts with brake fluid. Install a new seal on the plunger. Assemble the plunger, spring retainers, wave washer, and valve stem. Lubricate the plunger, seal and cylinder bore with brake fluid. Install the plunger and spring assembly in the cylinder bore. Install the push rod, retainer washer, seal, and push rod. Install a new **boot** over the push rod and onto the cylinder.

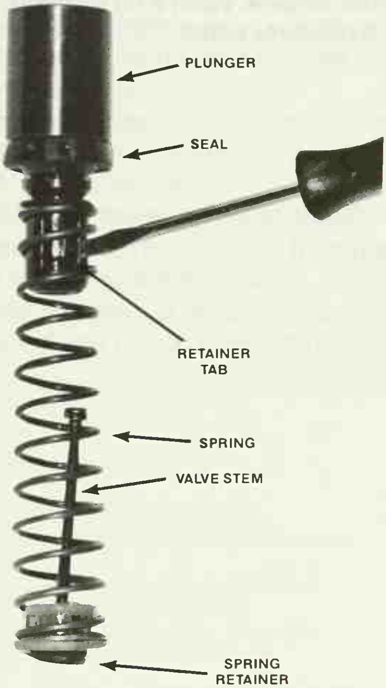


Figure 3-23. Removing spring and stem from a clutch cylinder plunger. (American Motors Corporation)

To reinstall the clutch cylinder, position the clutch cylinder on the dash panel. Align the mounting holes in the cylinder with the bracket studs and install the cylinder attaching nuts. Connect the cylinder push rod to the clutch pedal. Use a new cotter pin. Connect hydraulic lines to the cylinder. Fill the hydraulic reservoir with brake fluid and bleed the system as described in a later section. Install the power brake unit and master cylinder.

To remove the slave cylinder, raise the automobile. Disconnect the hydraulic line at the slave cylinder. Disconnect the spring from the cylinder push rod. Remove the bolts attaching the cylinder and heat shield to the clutch housing and remove the cylinder. **Safety Note:** ***Raise the vehicle with a suitable jack and place safety stands under the frame.***

To overhaul the slave cylinder, clean the cylinder exterior thoroughly. Remove the cylinder push rod, boot, plunger, and spring as assembly (Figure 3-24). Remove the spring and seal from the plunger. Take off the snap ring that retains the push rod in the plunger and remove the push rod and boot. Remove the boot from the push rod. Clean all parts with brake fluid. Install a new boot on the push rod. Place the push rod in the plunger and install a new push rod retaining snap ring. Replace the spring on the plunger. Lubricate the cylinder bore and seal with brake fluid. Install the plunger-spring-push rod assembly in the cylinder. Install and secure the boot on the cylinder. Install the pivot, washer and seal on the end of the push rod if these components remained on the push rod during the cylinder removal.

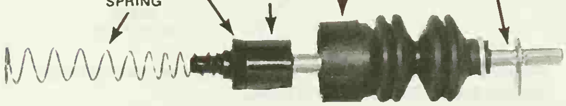


Figure 3-24. Parts of a slave cylinder assembly. (American Motors Corporation)

To reinstall the cylinder, position the heat shield on the cylinder. Align the push rod with the release lever, position the cylinder on the clutch housing and install the cylinder attaching bolts. Tighten the bolts securely. Connect the release lever spring to the cylinder push rod. Connect the hydraulic line to the cylinder. Lower the automobile. Fill the reservoir with brake fluid and bleed the hydraulic system as described in the next section.

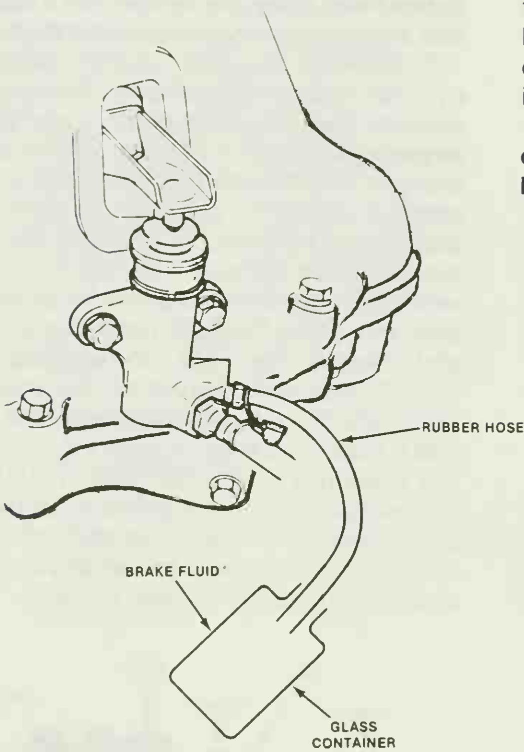


Figure 3-25. Bleeding removes air from a hydraulic clutch. (Nissan Motor Corporation in USA)

JOB COMPETENCY 3-11 BLEED A HYDRAULIC CLUTCH SYSTEM

When either the clutch cylinder or slave cylinder has been serviced, air enters the hydraulic system. The air must be removed by a procedure called **bleeding.**

Fill the reservoir with brake fluid. Attach one end of a rubber hose to the slave cylinder bleed screw. Place the opposite end of the hose in a glass container half full of brake fluid. Be sure the hose end is submerged in fluid as shown in Figure 3-25. Loosen the bleed screw. Have someone press and hold the clutch pedal to the floor. Tighten the bleed screw and release the pedal. Repeat the bleeding operation until fluid entering the container is free of bubbles. Do not let the reservoir run out of fluid during the bleeding operation. Fill to the level indicated on the reservoir after completing the bleeding operations.

CAUTION: DO NOT let brake fluid remain on a painted surface. Wash it off immediately because it removes paint.

NEW TERMS

Ball stud A rod with a round bearing joint at one end.

Bleeding A procedure used to remove air from a hydraulic clutch assembly.

Boot Flexible rubber covering used to keep dirt out of a part.

Cable-operated clutch linkage Clutch linkage operated by a flexible metal cable.

Clutch chatter A shaking or shuddering of the vehicle as the clutch is operated.

Clutch disc alignment tool A tool used to line up the clutch disc with the pressure plate during assembly.

Clutch drag A problem in which the clutch disc does not come to complete stop after the clutch pedal is depressed.

Clutch slippage A condition in which the engine overrevs during shifting or acceleration.

Free play Movement of linkage that does not result in movement of the connecting part.

Housing misalignment A condition in which the clutch housing does not line up with the other clutch components.

Pedal free play The free movement of the clutch pedal before the release bearing works the release levers.

Pedal free travel Same as pedal free play.

Pedal height The distance from the floor to the top of the clutch pedal.

Pedal pulsation A rapid up and down movement of the clutch pedal during operation.

JOB COMPETENCY TEST

1. How is clutch pedal free play determined?
2. What should the mechanic listen for during a clutch road test?
3. What can cause a clutch to slip?
4. What can cause clutch pedal pulsation?
5. How is a release bearing cleaned?
6. What tool is used to check for clutch housing misalignment?
7. How is a clutch disc centered when it is installed?
8. How are the clutch cover bolts tightened during clutch installation?
9. How can the direction of a clutch disc be determined during installation?
10. Why is it necessary to bleed a hydraulic clutch after service?

CERTIFICATION PRACTICE

1. Mechanic A says a clutch will slip if it has excessive free play.
   Mechanic B says a clutch will slip if it has too little free play.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. A clutch slips badly under acceleration.
   Mechanic A says there may be oil on the clutch plate.
   Mechanic B says pressure plate springs may be weak.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
3. A clutch makes a whirring noise as the pedal is depressed.
   Mechanic A says the problem is a broken pressure plate spring.
   Mechanic B says the problem is a worn release bearing.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
4. Clutch housing misalignment is determined with
   a. Micrometer
   b. Feeler gage
   c. Scale
   d. Dial indicator
5. When a vehicle shakes during clutch operation, this condition is called:
   a. Pulsation
   b. Chatter
   c. Drag
   d. Slippage

ANSWERS

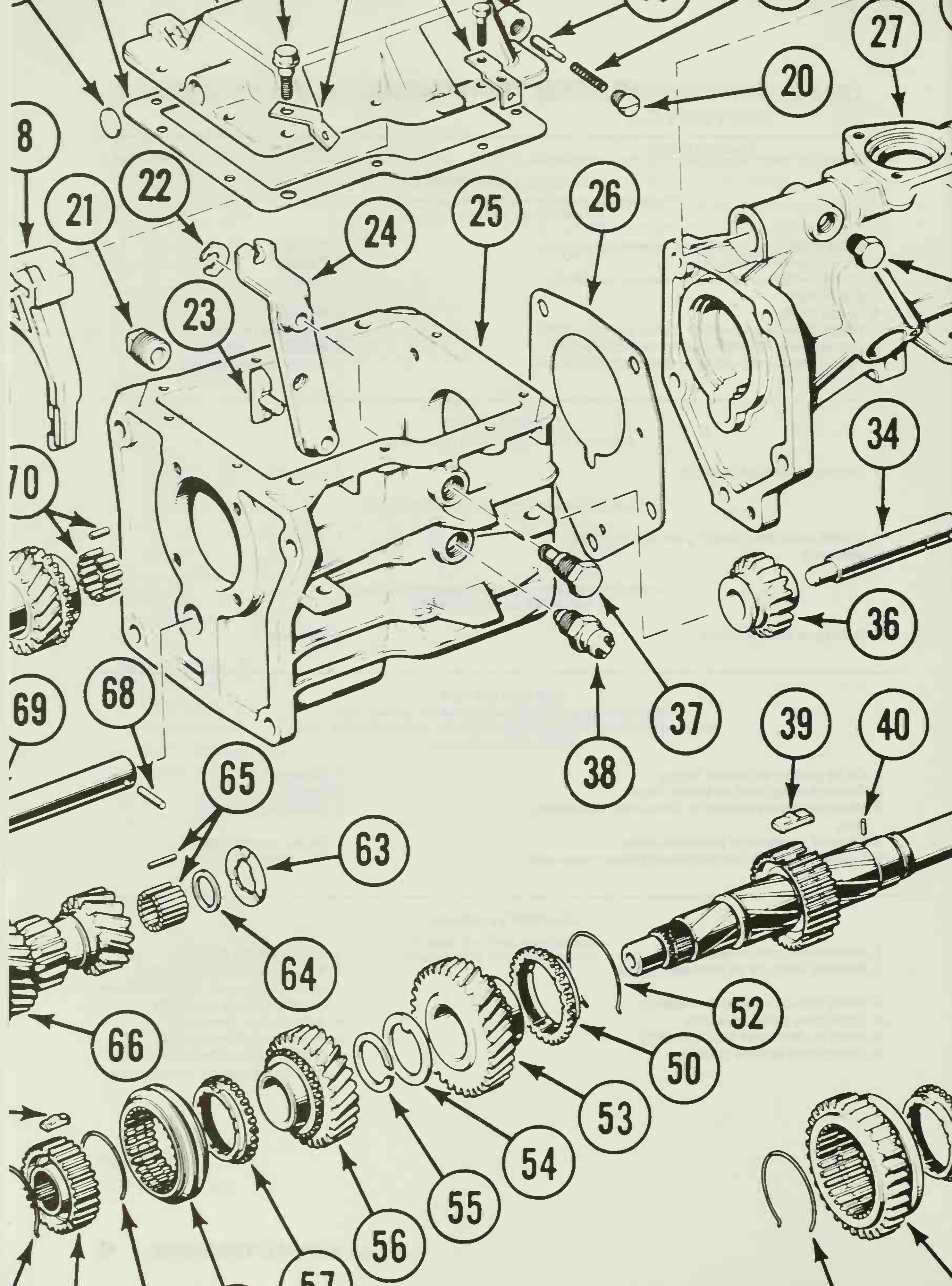
1. b, 2. c, 3. b, 4. d, 5. b

DISCUSSION TOPICS AND ACTIVITIES

1. Perform a clutch diagnosis and determine the cause of a clutch problem.
2. Look up the procedure and specifications for clutch replacement of a vehicle of your choice. Do the clutch service required.

CLUTCH TECH CHECK

Possible Cause	Service
CLUTCH CHATTERS — *Clutch chattering is usually noticeable when vehicle is just rolled off with clutch partially engaged*	
1. Weak or broken clutch disc torsion spring	1. Replace
2. Oil or grease on clutch facing	2. Replace
3. Clutch facing out of proper contact or clutch disc runout	3. Replace
4. Loose rivets	4. Replace
5. Warped pressure plate or clutch cover surface	5. Repair or replace
6. Unevenness of diaphragm spring toe height	6. Adjust or replace
7. Loose engine mounting or deteriorated rubber	7. Retighten or replace
NOISY CLUTCH — *A noise is heard after clutch is disengaged*	
1. Damaged release bearing	1. Replace
A noise is heard when clutch is disengaged	
1. Clutch cover and bearing are not installed correctly	1. Adjust
A noise is heard when vehicle is suddenly started off with clutch partially engaged	
1. Damaged pilot bushing	1. Replace
CLUTCH GRABS — *When grabbing of clutch occurs, vehicle will not start off smoothly from a standing start or clutch is engaged before clutch pedal is fully depressed.*	
1. Oil or grease on clutch facing	1. Replace
2. Clutch facing worn or loose rivets	2. Replace
3. Wear or rust on splines in drive shaft and clutch disc	3. Clean or replace
4. Warped flywheel or pressure plate	4. Repair or replace
5. Loose mountings for engine or power train units	5. Retighten
CLUTCH SLIPPING — *Engine over revs and does not provide power to drive wheels.*	
1. Insufficient pedal free play	1. Adjust clutch free play
2. Burned, worn, or oil soaked facings	2. Replace disc assembly and correct cause of contamination
3. Weak or broken pressure spring	3. Replace cover assembly
4. Excessive pedal free play	4. Adjust clutch free play
5. Worn or damaged disc assembly	5. Replace disc assembly
6. Clutch disc splines sticking	6. Remove disc assembly and free up splines or replace disc



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Unit 4

Manual Transmission

The purpose of a transmission is to multiply the engine's turning effort or torque to allow the automobile to move efficiently from a dead stop to highway speed. A transmission may be controlled automatically or manually by the driver. We are concerned in this unit with transmissions that are controlled manually. These units are often called manual or standard transmissions. The term **standard** originated when a manual transmission was provided as standard equipment and an automatic transmission was optional equipment. In this unit you will learn how the manual transmission operates.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe how a system of gears can be used to multiply torque.
2. Explain the relationship of the number of gears to the direction of rotation in a gear system.
3. Describe how a basic transmission works to help a vehicle start moving.
4. Trace the power flow through a three-speed transmission.
5. Trace the power flow through a four-speed transmission.

TORQUE MULTIPLICATION

The transmission helps the engine start the vehicle moving from a standstill and accelerate to road speed. The engine and transmission work as a team.

The drive wheels of the vehicle rotate to drive the vehicle. The twisting or turning effort to rotate the tires is called **torque.** Torque is developed by the engine. The problem is that the engine alone cannot develop enough torque to get the vehicle moving from a standstill. The engine needs help also during acceleration and hill climbing.

The torque that a typical gasoline engine can produce can be measured and plotted

on a graph similar to the one in Figure 4-1. The unit of measurement for torque in the customary measuring system is foot-pound. In the metric system, torque is expressed in newton-metres. The torque is shown at various engine speeds (revolutions per minute or rpm).

Different engines, of course, describe different curves, but they are all similar. At low engine rpm, torque is low. As engine rpm increases, torque increases up to a point in the rpm range at which the engine will have trouble breathing in enough air and fuel. At this point the torque curve will begin to drop off. The transmission must work to overcome low torque at low rpm. The transmission at the lower gear ratios allows the engine to operate at higher speeds during low vehicle speeds so the engine can operate at, or near, its best torque range. The transmission's job is **torque multiplication:** that is, to multiply the engine's low initial torque to get the vehicle moving and to meet varying road conditions.

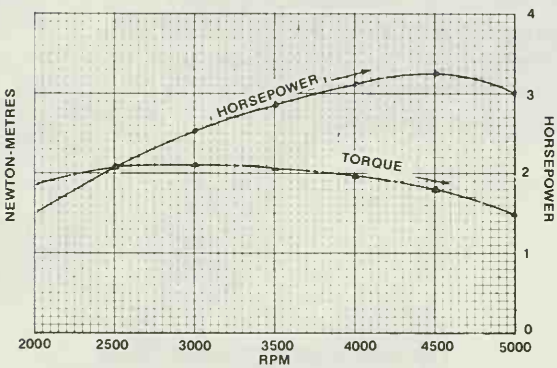


Figure 4-1. The torque of an engine is low at low speed and must be multiplied by the transmission. (Go-Power Systems)

GEARS MULTIPLY TORQUE

Engine torque is multiplied in a transmission with a system of **gears.** In order to understand how a gear can multiply torque let's begin with an ordinary lever. Figure 4-2 **top** shows a 20-inch lever supported in the center on a point called a **fulcrum.** Since the fulcrum is in the center, a 100-pound force down at A exerts a 100-pound force up at B. This is because the weights are positioned at equal distances from the fulcrum. We could, however, put a heavier weight on the right side but closer to the fulcrum as shown in Figure 4-2, **bottom.** Now a 100-pound force at A exerts a 200-pound force at C.

Let us change the fulcrum into a shaft, fastened solidly to the lever as shown in Figure 4-3. If a force pushes down on one end of the lever, this applies a twist, or torque,

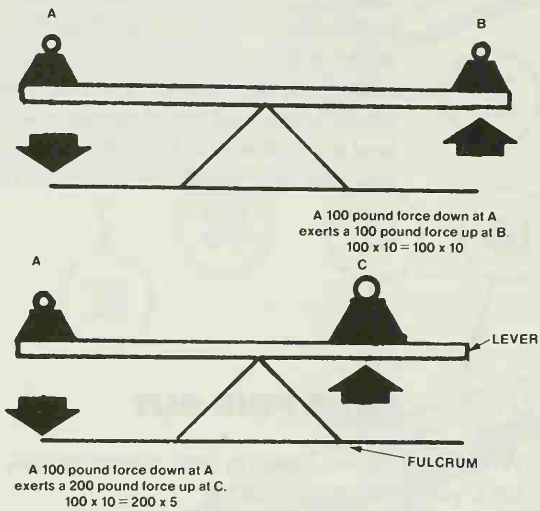


Figure 4-2. Operation of a lever and fulcrum. (General Motors Corporation)

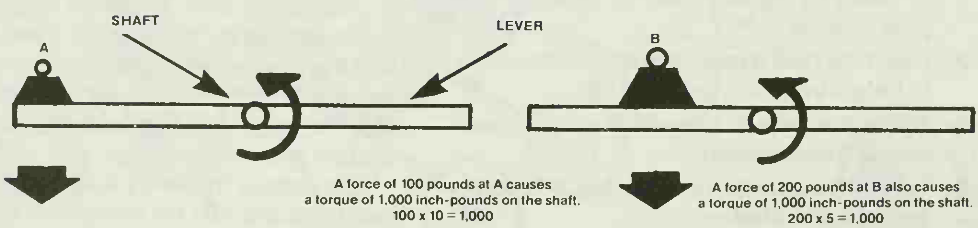


Figure 4-3. A shaft and lever work like a fulcrum. (General Motors Corporation)

to the shaft. Now suppose we turn things around the other way, and have the shaft try to turn the lever. If the shaft is exerting a torque of 1000 inch-pounds it will create a force of 100 pounds at A, or 200 pounds at B. (An inch-pound is one-twelfth of a foot-pound.)

Now let us take two of these levers, one 10 inches long and the other 20 inches long. Arrange them so one end of the short one is resting on one end of the long one. A torque of 500 inch-pounds is applied to the shaft of the shorter one. There will be a force of 100 pounds down at A, the end of the short lever (100 x 5 = 500). This will exert the same force, 100 pounds, down at B, the end of the long lever. This force will create a torque on the second shaft of 1000 inch-pounds (100 x 10 = 1000). Our input torque was 500 inch-pounds, and our output torque is now 1000 inch-pounds, because the lever is longer (Figure 4-4).

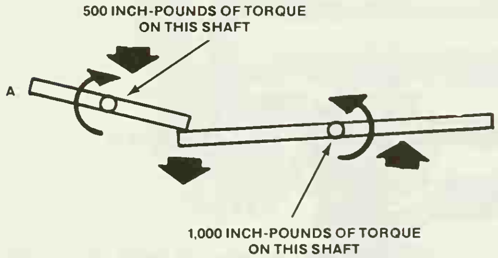


Figure 4-4. Two levers and shafts acting together multiply torque. (General Motors Corporation)

Two levers working together would multiply torque but would not move the shaft very far. In order to keep the shaft moving a set of levers is arranged in a circle. When we fill in the center of the levers we have a set of gears as shown in Figure 4-5. A gear is simply a spinning lever.

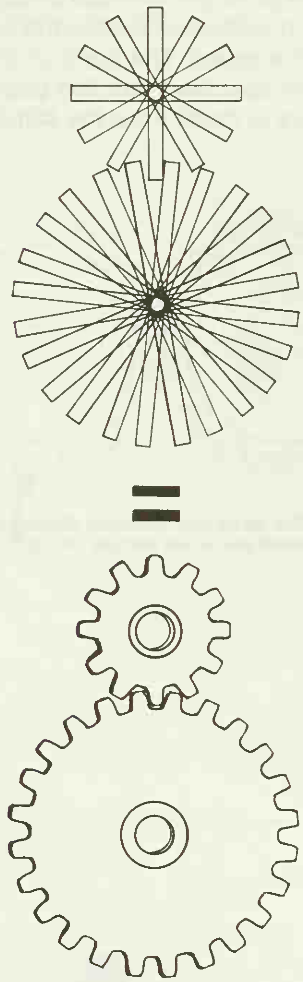


Figure 4-5. Gears are a set of levers arranged in a circle. (General Motors Corporation)

GEAR RATIO

When a small gear is used to turn a large one, the small gear turns around several times before the big one has made a complete revolution. This means that the engine connected to a small gear would turn at higher rpm than the rear wheels connected to the big gear. The speed difference, as well as the amount of torque increase through a gear mechanism, is determined by the number of teeth on the gears. The number of teeth is not usually specified, but the **gear ratio** is. If two gears in mesh have the same number of teeth, they will turn at the same speed and will not multiply torque (Figure 4-6). The ratio is determined by dividing the number of teeth on the small gear into the number of teeth on the larger gear. Thus, if a small gear in Figure 4-7 with 15 teeth turns a larger gear with 45 teeth, the ratio is 3 to 1. We sometimes use the term "speeds" to describe ratios.

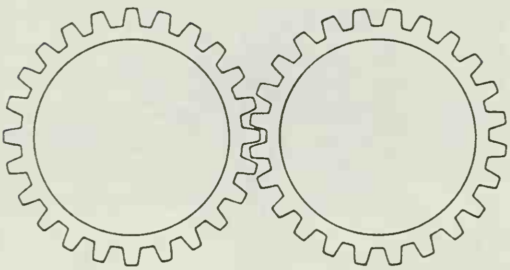


Figure 4-6. Two gears with the same number of teeth turn at the same speed and do not multiply torque.

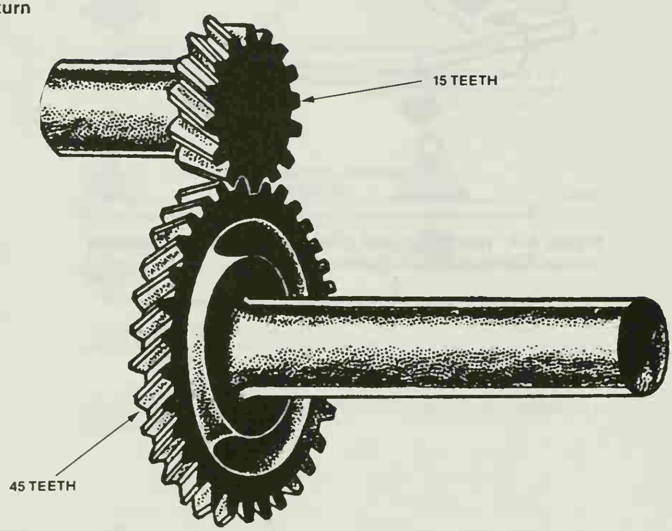


Figure 4-7. The gear ratio three to one (3:1) is determined by dividing the number of teeth on the small gear into the number on the larger gear. (General Motors Corporation)

GEAR DIRECTION

Gears can be used not only to multiply torque, but also to change the direction torque is applied. When two gears are in mesh, the direction of rotation is reversed. That is, if one gear turns clockwise the meshing gear turns counterclockwise as shown in Figure 4-8.

If we want the direction of rotation to be the same, we must use three gears. If we place a gear between two gears as shown in Figure 4-9 we can get the outside gears to turn in the same direction. The gear in the middle is called an **idler** or **floating gear**. It is free to turn on an idler shaft. When gear A is turned counterclockwise, the idler gear turns clockwise and drives gear B counterclockwise. Since the idler gear "floats," it does not affect the gear ratio between gear A and B. Any number of gears can be used in a transmission. An even number of gears (2, 4, 6, etc.) always reverses the direction of rotation. An odd number (3, 5, 7, etc.) will keep the same direction of rotation.

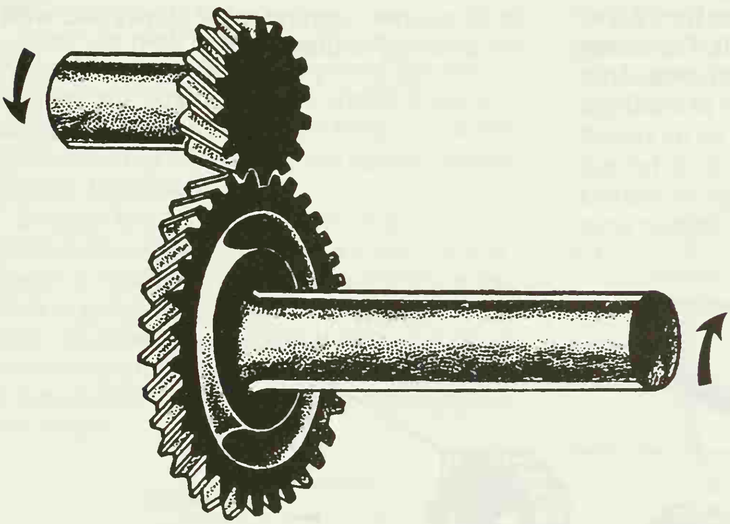


Figure 4-8. When two gears are in mesh, the direction of rotation is opposite for each gear. (General Motors Corporation)

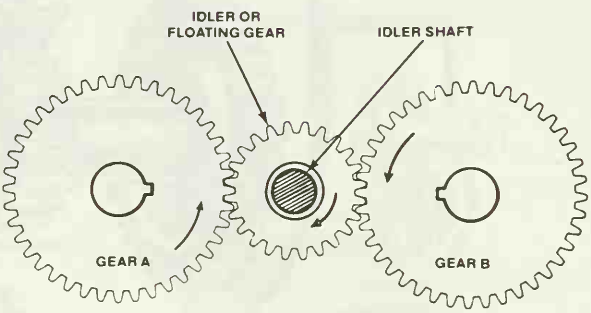


Figure 4-9. A floating or idling gear allows gears to turn in the same direction. (Chrysler Corporation)

BASIC TRANSMISSION

A transmission uses a system of gears to vary the speed and torque of the drive axle in relation to the speed and torque of the engine. The transmission is located behind the clutch, and its case is usually fastened to the clutch housing. In this section we will build up a simple set of gears to see how a basic transmission works. We will begin with a transmission that has three speeds or three forward gear ratios.

First speed, or low gear, is used for starting and for steep hills or heavy going in sand or mud. It lets the engine run fast while the vehicle moves slowly. The engine runs 2½ to 3 times as fast as the drive shaft. The exact amount varies in different vehicles. This means, of course, that the torque of the drive shaft is increased just as much as its speed is cut down. Thus we have a lot of torque on the rear wheels to get the vehicle started from a standstill, or for use at any other time we need it.

This is done with four gears and three shafts as shown in Figure 4-10. A small gear on the shaft from the engine drives a larger gear fastened to the transmission **counter-shaft.** Another smaller gear fastened on the countershaft drives a large gear on the third shaft. This last shaft goes to a universal joint on the front end of the driveshaft. Thus we have the same arrangement shown earlier. There is a speed reduction in the first two gears, and then more reduction in the second set of two gears. The countershaft is running at a speed in between the speeds of the other two shafts. And the third shaft is, of course, running most slowly and with the greatest torque.

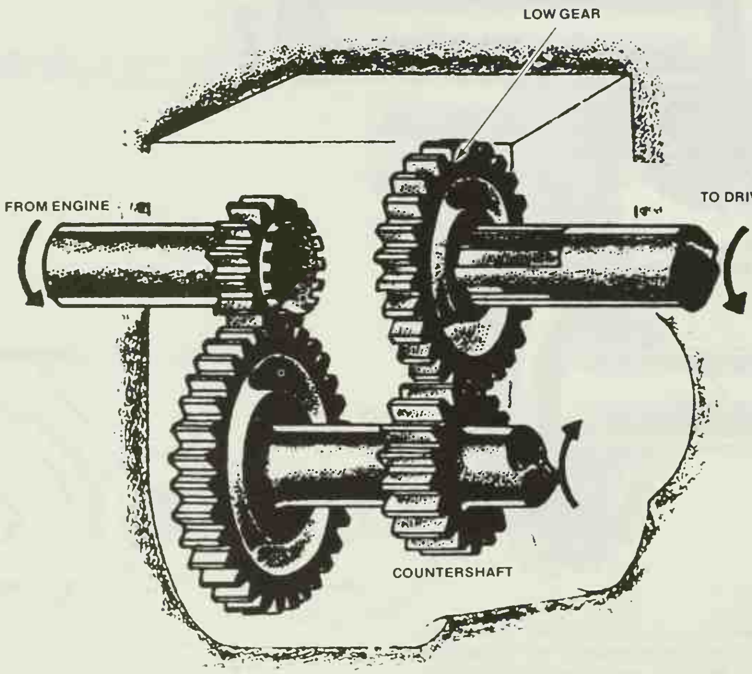


Figure 4-10. First gear or low gear. (General Motors Corporation)

Second gear works in about the same way. The first two gears are the same as we used in low gear. Gears in the next pair are different, however, as shown in Figure 4-11. They are almost the same size, and sometimes the countershaft gear may be the larger. Thus the countershaft runs at the same speed as before, but there is little if any additional reduction from that to the third shaft. So for the same engine speed the wheels will run faster than they did in low gear. The usual ratio in second speed is around $1^2/_3$ to 1. This means that the drive shaft will run at 1,000 rpm when the engine is running at 1,670 rpm.

Third, or high speed, is direct drive. The transmission does not do anything. We simply connect the first and third shafts together, as shown in Figure 4-12, and they turn at the same speed as the engine, and deliver engine torque. The ratio is 1 to 1.

Besides forward speeds, there are two other combinations we can get in a transmission. There is neutral, in which the transmission shaft is entirely disconnected from the clutch shaft, and the engine cannot drive the drive shaft or anything beyond the transmission. It has about the same effect as disengaging the clutch.

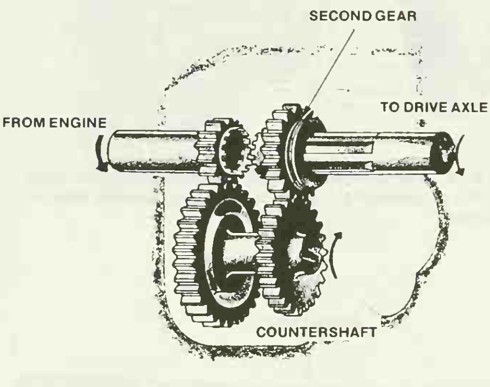


Figure 4-11. Second gear. (General Motors Corporation)

There is also a reverse gear to back up the vehicle. It is difficult to make an internal combustion engine run backwards, so it runs it in one direction all the time and uses gears to reverse the direction of rotation. There is an extra gear between the countershaft and the final drive shaft, called a **reverse idler.** The driven reverse idler in turn drives the low-speed gear on the final drive shaft as shown in Figure 4-13. The system is just like low gear except for the extra gear between low gear and the countershaft which changes the direction of rotation. The final shaft turns opposite to all the previous cases. The ratio of reverse is about the same as low gear, or even lower. We may want to pull hard in reverse, but we never want to back up very fast.

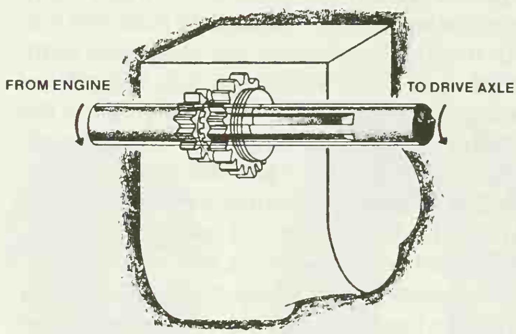


Figure 4-12. Third or high gear. (General Motors Corporation)

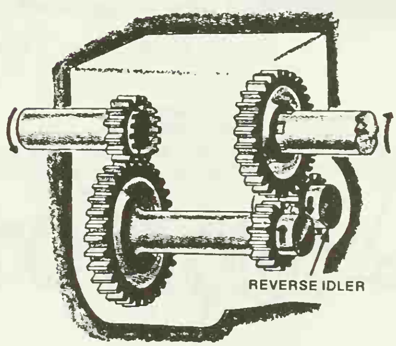


Figure 4-13. Reverse gear. (General Motors Corporation)

SYNCHRONIZERS

By moving the shift lever in the driving compartment the driver selects the gears to be used in the transmission. Gear shifting on older transmissions required that the gears be moved in and out of mesh with each other, which meant a lot of careful driving technique to avoid clashing of gears. Now transmissions use synchronizers for shifting. The gears in the transmission remain in constant mesh with each other. When a particular gear is selected, a synchronizer locks the mainshaft gears to the mainshaft so that engine power can be transferred through them. The unit works to synchronize the speed of the shaft and the gear so they may be locked up without any clashing.

A simplified synchronizer is shown in Figure 4-14. The two shafts are not connected together. When we want to connect them together we use shift linkage to push the hub with internal teeth over the matching teeth on the first shaft. When the hub has moved forward it connects the two shafts. Since the two shafts may be turning at different speeds it may be difficult to get the hub in mesh. For this reason a synchronizer uses a cone clutch to synchronize the speed of the two shafts before the hub slips into mesh.

The synchronizer consists of a sleeve that is moved back and forth on a hub, attached to the output shaft. A synchronizer is shown in Figure 4-15. A bronze synchronizer ring is placed on each side of the hub. The ring has a coned or tapered inside surface, matched to the corresponding gear or the shaft. The driver moves the shift linkage to lock up a gear. The sleeve is moved toward the gear along the teeth of the hub. The sleeve begins to contact the synchronizer ring. The synchronizer ring is pushed in contact with the gear. The matching surfaces of the ring and gear act as a clutch. As soon as they touch, the gear and output shaft begin to turn at the same speed. The sleeve can then be moved far enough to lock onto the gear, which is locked to the sleeve and through the hub to the output shaft.

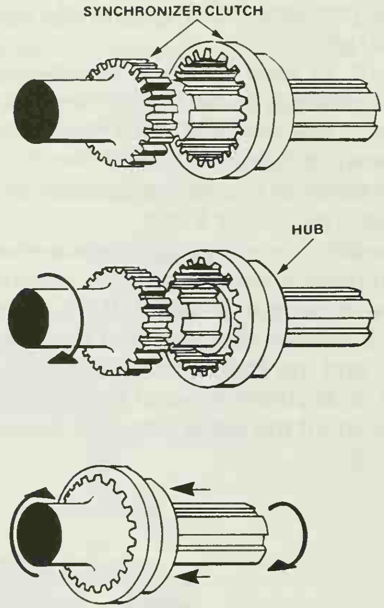


Figure 4-14. A synchronizer clutch is a device that connects two shafts or connects a gear to a shaft. (General Motors Corporation)

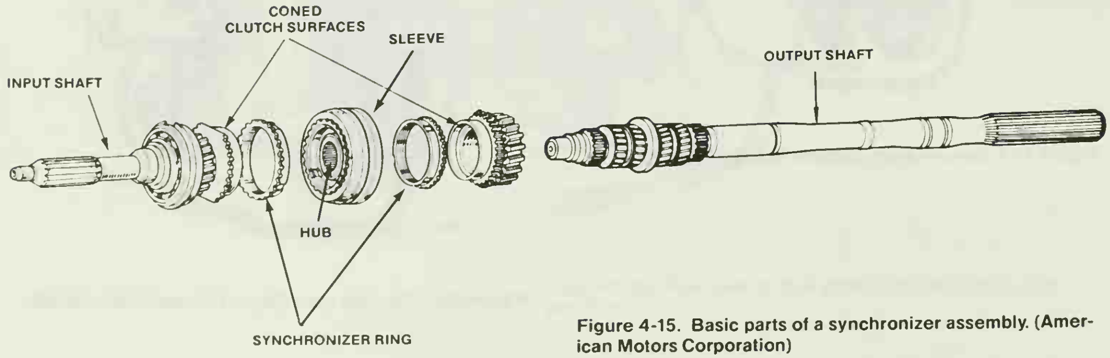


Figure 4-15. Basic parts of a synchronizer assembly. (American Motors Corporation)

An exploded view of a synchronizer assembly is shown in Figure 4-16. This is the synchronizer for first or low gear and is similar to the unit used on each synchronized gear in the transmission. There are three keys that slide in slots of the hub and these keys are spring-loaded by two synchronizer springs. Between the hub and gear a synchronizer ring is installed which, together with the cone surface, acts as a friction clutch. The synchronizer ring has three slots in which the keys engage, and it is thereby moved along and up on the coned surface when the sleeve is pushed forward. The slots in the synchronizer ring are wider than the keys, so that the synchronizer ring can rotate a small amount relative to the hub.

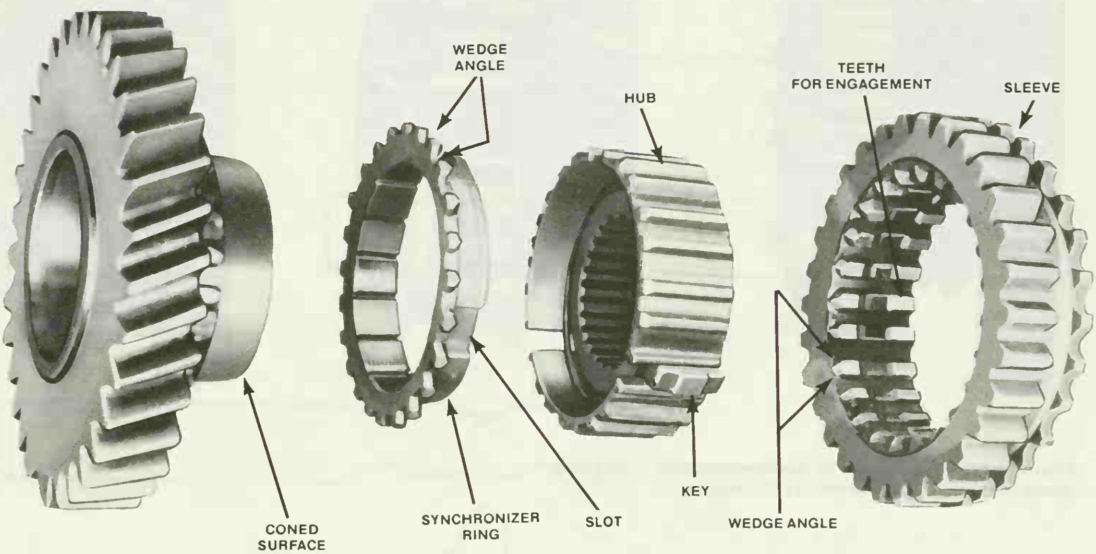


Figure 4-16. Exploded view of a synchronizer assembly. (Chevrolet Division of General Motors Corporation)

The internally splined synchronizer sleeve slides along the external splines of the hub. The sleeve splines have a shallow groove in which rest the raised parts of the keys when in neutral position. Each spline of the sleeve and each tooth of the synchronizer ring have a wedge angle on both sides. Through the press of these wedge angles, gears cannot engage until the synchronizer ring has brought the gear to the speed of the hub. The engagement of the synchronizer is shown in Figure 4-17.

SHIFTING CONTROL

Shifting from one gear to another in a transmission is accomplished by locking or unlocking gears to their shafts with synchronizer assemblies. Locking and unlocking of the synchronizer is done by moving the synchronizer sleeves back and forth. Each synchronizer sleeve has a groove cut in its outside diameter. A **shifting fork** fits into each of the sleeve grooves (Figure 4-18). Linkages connected to the forks allow the driver to move the sleeves and position the transmission in the desired gear.

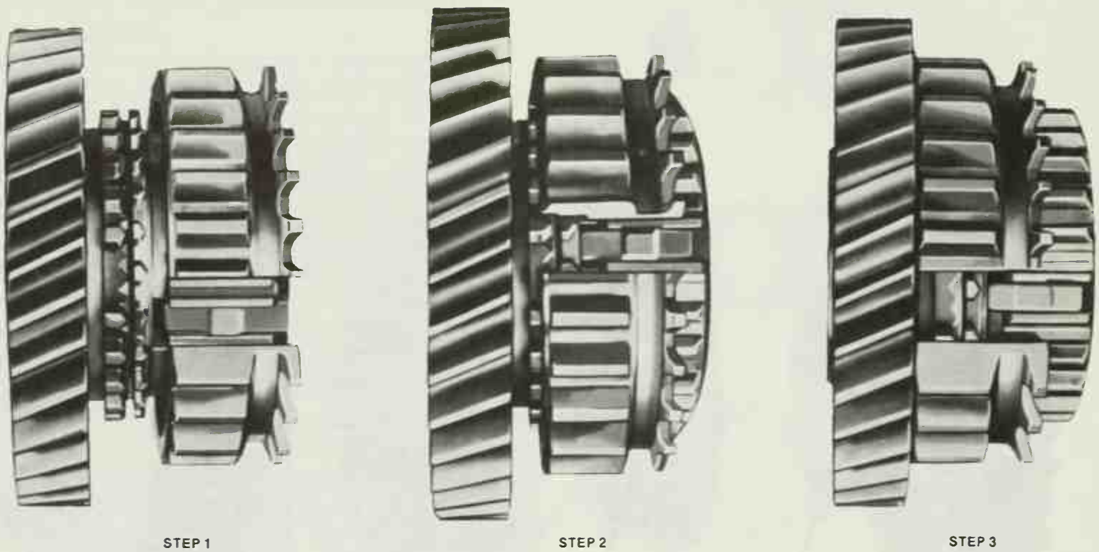


Figure 4-17. Engagement of the synchronizer. (Chevrolet Motor Division of General Motors Corporation)

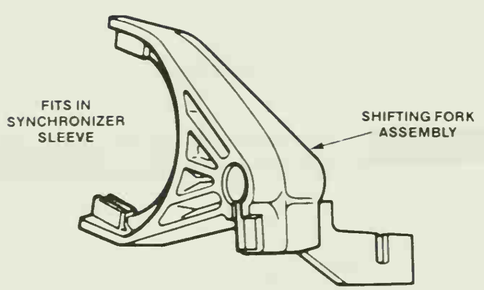


Figure 4-18. The shifting forks are positioned in the synchronizer sleeve. (American Motors Corporation)

The shifting forks are mounted inside the transmission on shafts called **shift rails** (Figure 4-19). The rails can be moved back and forth to allow positioning of the forks. The travel of the rails must be carefully controlled so that only the gear selected is engaged and so that more than one gear is not engaged at one time. There are a number of small holes in the shift rails into which fit small metal **detent** plugs or **interlock** cams. These plugs are spring-loaded into the transmission case. These plugs drop into the rail when it has moved into the required position. Moving it out of this position can only be accomplished by movement of the gear shifting linkage. The shifting-fork and rail assembly is often mounted to a side or top cover on the transmission that is removable for service.

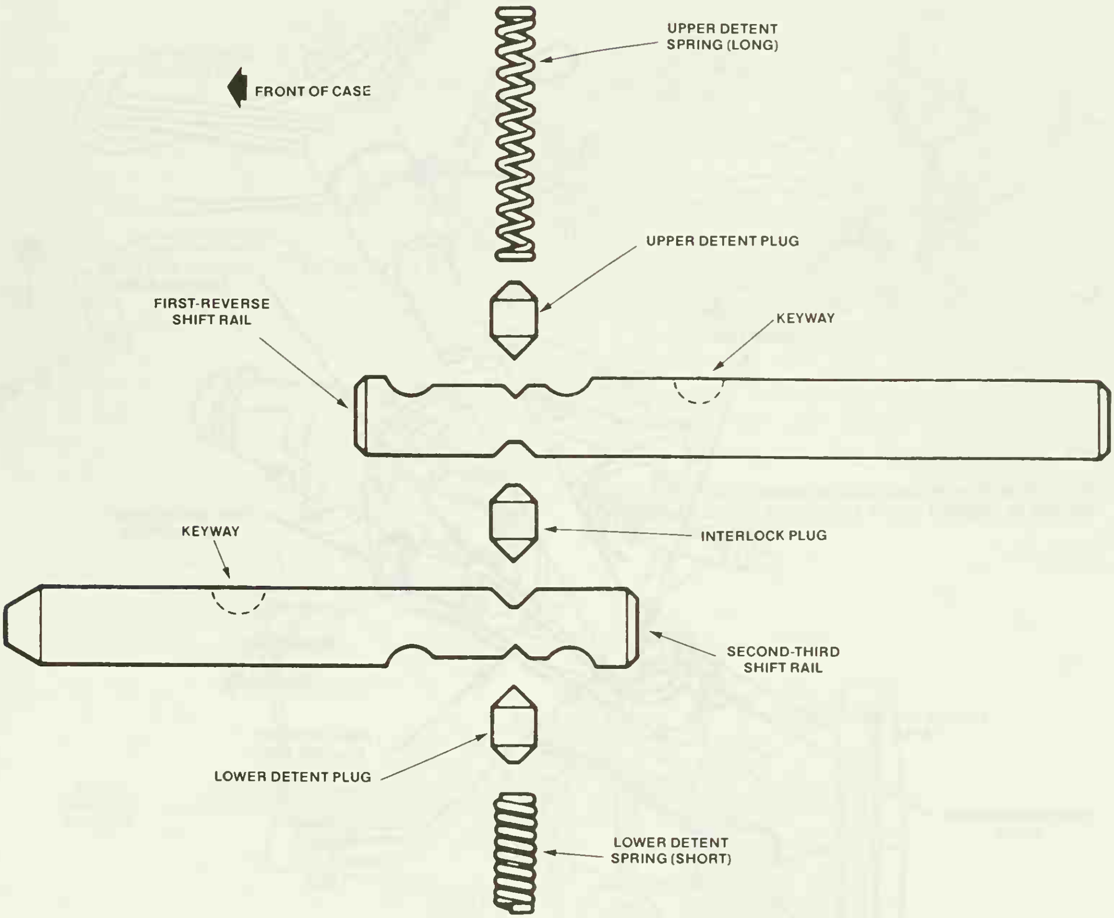


Figure 4-19. The shift rails and detent plugs prevent two gears from meshing at one time. (American Motors Corporation)

Control linkage from the shifting forks to the driving compartment may either be a **column shift** or a **floor shift.** With a column shift, the shift linkage is attached to the side of the steering column. A column shifting assembly is shown in Figure 4-20. This assembly is common to older vehicles and current trucks. Two control rods run from the column to the shift forks. One controls the second and third shift fork, and the other controls the first and reverse shift fork. An interlock system prevents two gears from being activated at one time.

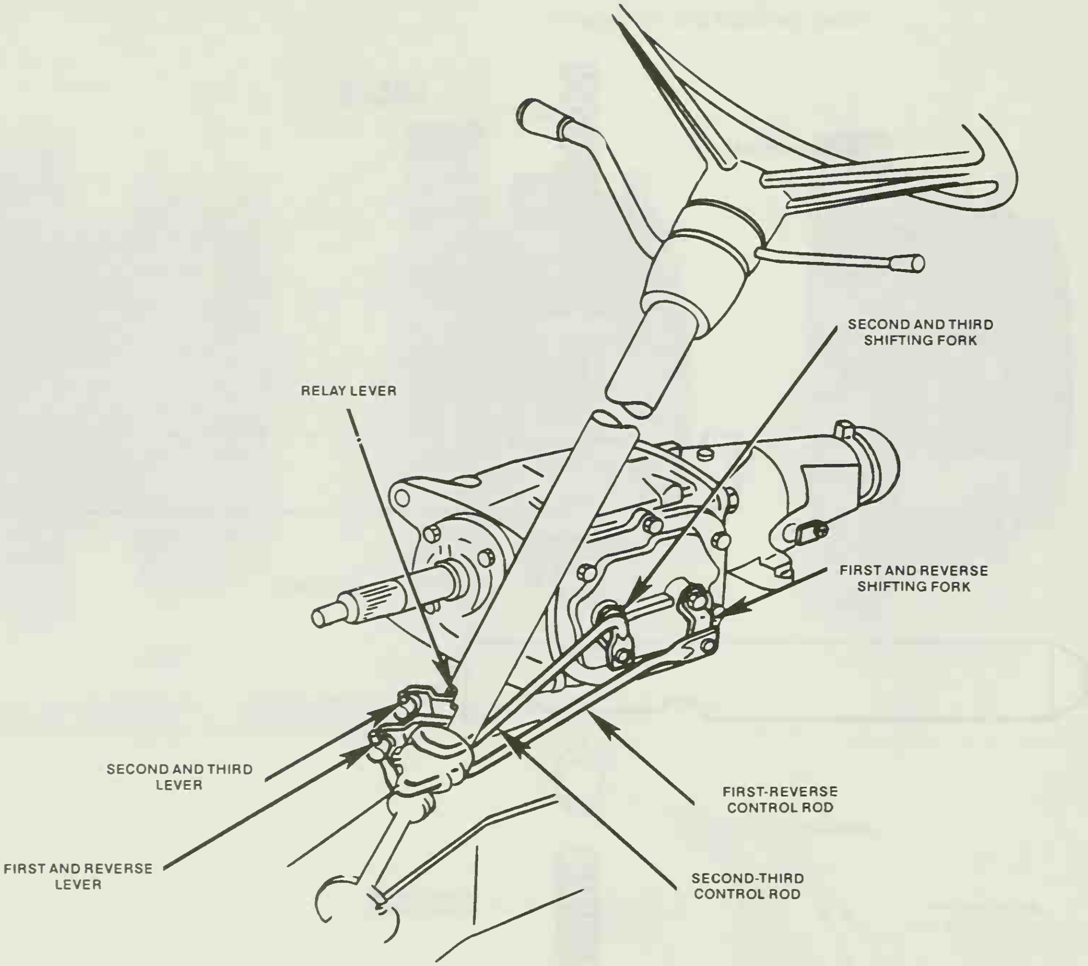


Figure 4-20. Shifting forks may be controlled by linkage to the steering column. (General Motors Corporation)

Floor shift linkage is the most common type of shift linkage because it is more direct and requires a less complicated linkage system. Two general styles are used. The one in Figure 4-21 uses a floor-mounted shift lever and control rods connected to the transmission shift forks. The unit in Figure 4-22 has a housing with the shift forks and shift linkage that is mounted to the transmission and comes up through the floor. In either case, moving the control lever causes movement of the linkage which, in turn, positions the shifting fork and synchronizers for the correct gear. Interlocks are used to prevent more than one gear from engaging.

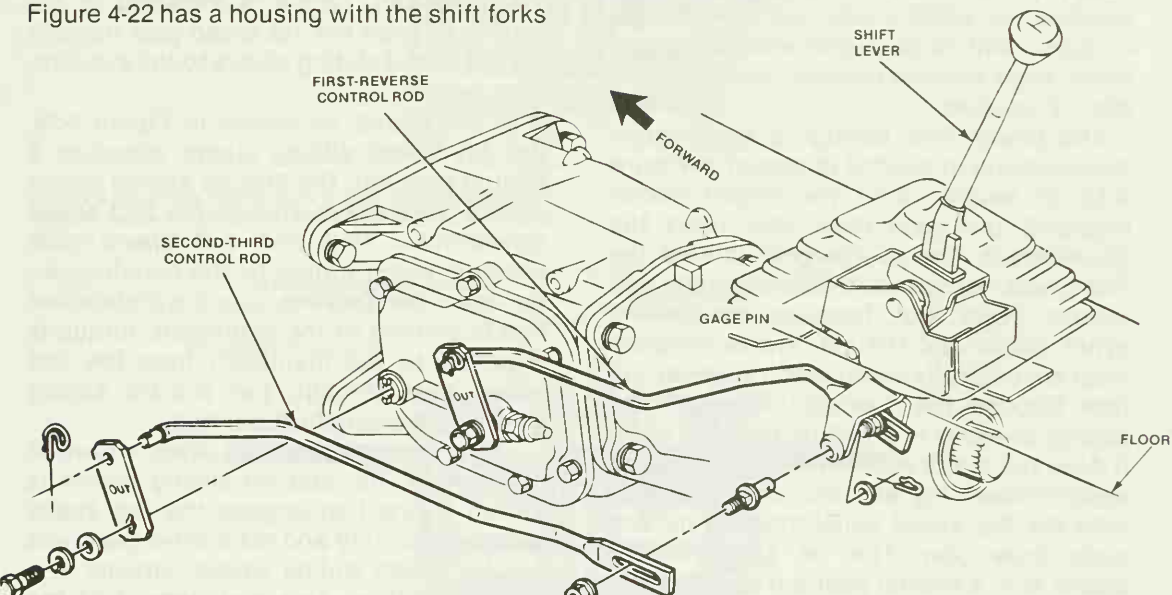


Figure 4-21. Floor-mounted shift linkage with control rods to the transmission. (Chevrolet Motor Division of General Motors Corporation)

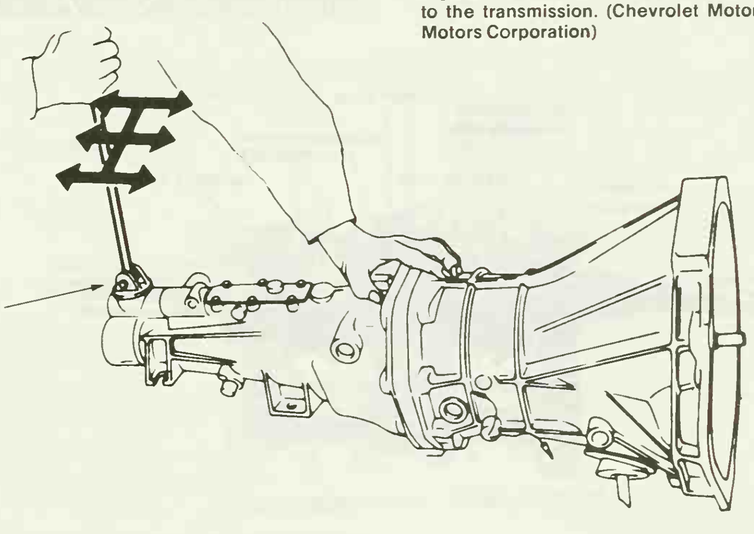


Figure 4-22. Shift control and fork housing mounted to the transmission. (Nissan Motor Corporation in USA)

POWER FLOW THROUGH A THREE-SPEED TRANSMISSION

In a previous section we described the operation of a basic **three-speed transmission**. In this section we will examine the way power flows through an actual three-speed transmission. Three-speed transmissions are common on small trucks and on vehicles equipped with large displacement engines where large amounts of torque multiplication are not required.

The power flow through a three-speed transmission in neutral is shown in Figure 4-23. In neutral, with the engine clutch engaged, the main drive gear turns the countergear. The countergear rotates the 2nd speed, 1st speed, and reverse idler and reverse gears. But, because the 2nd-3rd synchronizer and the 1st-reverse synchronizer are neutrally positioned, no power will flow through the mainshaft. The 2nd-3rd sliding sleeve is in a neutral position when it does not mesh with either the 2nd speed synchronizer ring and 2nd speed gear or with the 3rd speed synchronizer ring and main drive gear. The 1st speed sliding sleeve is in a neutral position when it does not mesh with either the 1st speed synchronizer ring and 1st speed gear or with the reverse gear.

The power flow in first speed or low gear is shown in Figure 4-24. In the 1st speed, the 1st speed sliding sleeve is moved forward to engage the 1st speed synchronizer ring and 1st speed gear (which is being turned by the countergear). Because the 1st speed synchronizer hub is splined to the mainshaft, torque is imparted to the mainshaft from the 1st speed gear through the 1st speed sliding sleeve to the synchronizer hub.

In 2nd speed, as shown in Figure 4-25, the 1st speed sliding sleeve assumes a neutral position. The 2nd-3rd sliding sleeve moves rearward to engage the 2nd speed synchronizer ring and 2nd speed gear which is being turned by the countergear. Because the 2nd-3rd speed synchronizer hub is splined to the mainshaft, torque is imparted to the mainshaft from the 2nd speed gear through the 2nd-3rd sliding sleeve to the synchronizer hub.

In third speed, or direct drive, shown in Figure 4-26, the 2nd-3rd sliding sleeve is moved forward to engage the 3rd speed synchronizer ring and main drive gear, and the 1st speed sliding sleeve remains in a neutral position. This engagement of the main drive gear with 2nd-3rd sliding sleeve imparts torque directly through the 2nd-3rd synchronizer hub to the mainshaft.

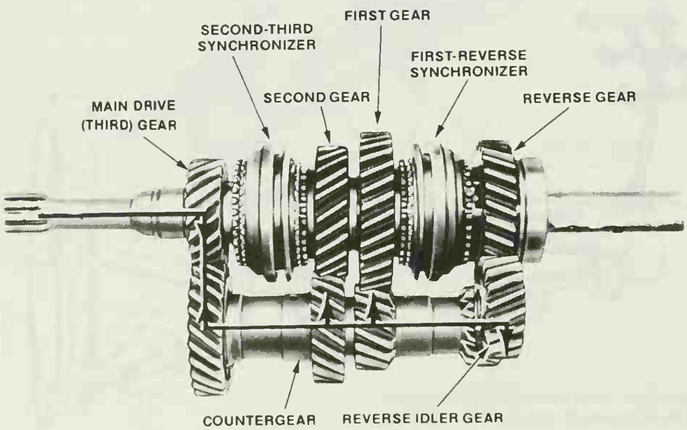


Figure 4-23. Power flow through a three-speed transmission in neutral. (Chevrolet Motor Power Division of General Motors Corporation)

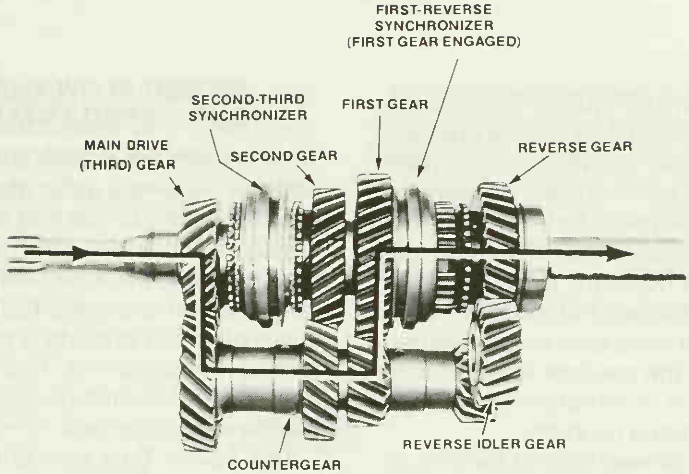


Figure 4-24. Power flow through a three-speed transmission in 1st speed or low gear. (Chevrolet Motor Division of General Motors Corporation)

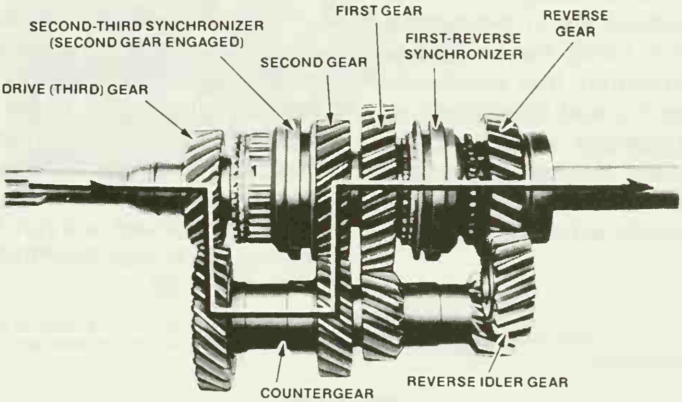


Figure 4-25. Power flow through a three-speed transmission in 2nd speed. (Chevrolet Motor Division of General Motors Corporation)

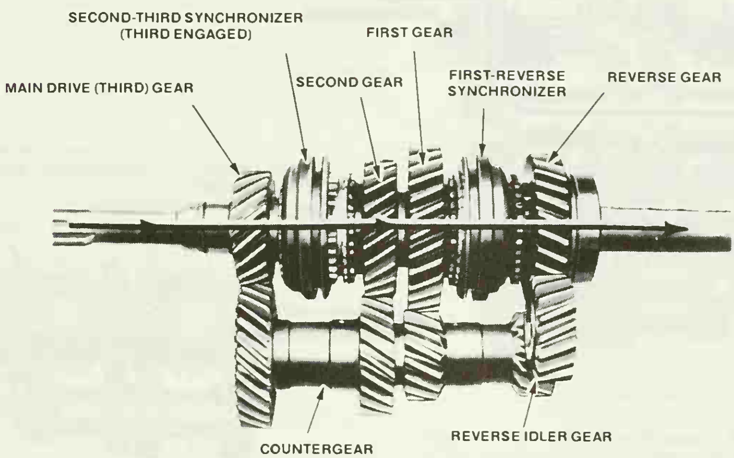


Figure 4-26. Power flow through a three-speed transmission in 3rd speed or high gear. (Chevrolet Motor Division of General Motors Corporation)

In reverse, shown in Figure 4-27, the 2nd-3rd sliding sleeve assumes a neutral position. The 1st speed sliding sleeve is moved rearward to engage the reverse gear. The reverse gear is held to the mainshaft through the 1st speed synchronizer assembly and the reverse gear is in constant mesh with the reverse idler gear. Because of this, the power flows from the main drive gear to the countergear and through the reverse idler gear to the reverse gear in a direction of rotation opposite that of engine rotation.

Note that for any forward gear or for reverse gear, only one synchronizer assembly is engaging a gear while the other synchronizer assembly is in a neutral position. If both synchronizer assemblies are in the neutral position, no power is being transmitted to the mainshaft. Remember this especially when you diagnose manual transmissions for malfunction. For example, if both synchronizer assemblies were engaging gears at the same time, the transmission would be locked up and no power would be transmitted through it.

POWER FLOW THROUGH A FOUR-SPEED TRANSMISSION

Vehicles with medium to small displacement engines require a good deal of torque multiplication to get moving from a standstill. These vehicles are often equipped with a transmission with four forward speeds. This transmission provides four forward gears, three of which provide a gear reduction or torque multiplication. This transmission requires an additional gear on both the mainshaft and countergear.

The power flow through the **four-speed transmission** is similar to that of the three-speed except that an additional set of gears is used.

In neutral, with engine clutch engaged, the main drive gear turns the countergear. The countergear then turns the 3rd, 2nd, 1st, and reverse idler gears. Since the 3rd-4th and 1st-2nd speed synchronizers are in neutral position, and the reverse-speed gear is positioned at the rear, away from the reverse idler gear, power will not flow through the mainshaft. Power flow in neutral is shown in Figure 4-28.

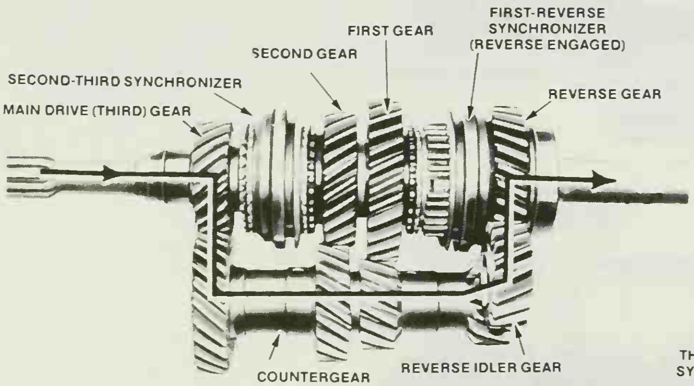


Figure 4-27. Power flow through a three-speed transmission in reverse gear. (Chevrolet Motor Division of General Motors Corporation)

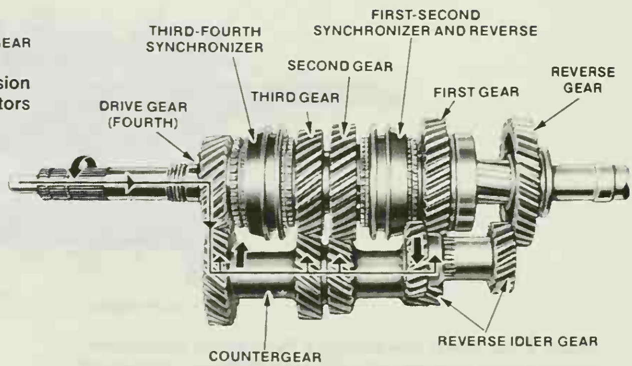


Figure 4-28. Power flow through a four-speed transmission in neutral. (Chevrolet Motor Division of General Motors Corporation)

In 1st speed, shown in Figure 4-29, the 1st and 2nd speed sleeve is moved rearward to engage the first speed gear which is being turned by the countergear. Because the 1st and 2nd speed hub is splined to the mainshaft, torque is applied to the mainshaft from the 1st speed gear through the clutch assembly.

In 2nd speed, shown in Figure 4-30, the 1st and 2nd speed synchronizer is moved forward to engage the 2nd speed gear, which is being turned by the countergear. This engagement of the synchronizer with the 2nd speed gear applies torque to the mainshaft because the 1st and 2nd speed synchronizer is splined to the mainshaft.

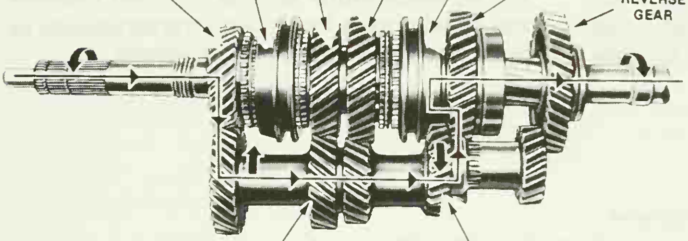


Figure 4-29. Power flow through a four-speed transmission in 1st speed or low gear. (Chevrolet Motor Division of General Motors Corporation)

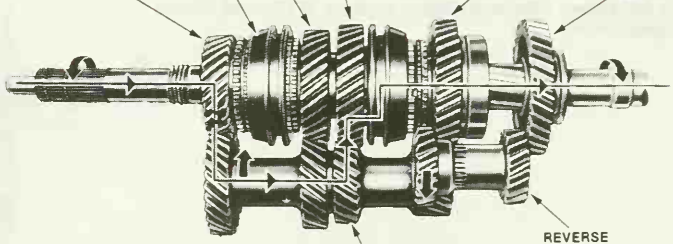


Figure 4-30. Power flow through a four-speed transmission in 2nd speed. (Chevrolet Motor Division of General Motors Corporation)

In 3rd speed, shown in Figure 4-31, the 1st and 2nd speed synchronizer is in the neutral position. The 3rd and 4th speed synchronizer moves rearward to engage the 3rd speed gear, which is being turned by the countergear. Because the 3rd and 4th speed synchronizer is splined to the mainshaft, torque is applied to the mainshaft from the 3rd speed gear through the synchronizer assembly.

In 4th speed, or direct drive, the 3rd and 4th speed synchronizer is moved forward to engage the main drive gear and the 1st and 2nd speed synchronizer remains in a neutral position as shown in Figure 4-32. This engagement of the main drive gear with the 3rd and 4th speed synchronizer applies torque directly to the mainshaft.

In reverse speed, both synchronizers are in neutral position. The reverse speed gear is moved forward to engage the rear reverse idler gear, which is being turned by the countergear. Because the reverse speed gear is splined to the mainshaft, this engagement causes the mainshaft to turn; however, because power flows from main drive gear to the countergear and through the reverse idler gear to the reverse speed gear, it turns in a reverse direction. The power flow in reverse is shown in Figure 4-33.

There are, of course, transmissions with more than four speeds. They may have five, six, or even more speeds. We will present the operation of five-speed transmissions in the unit on overdrive transmissions.

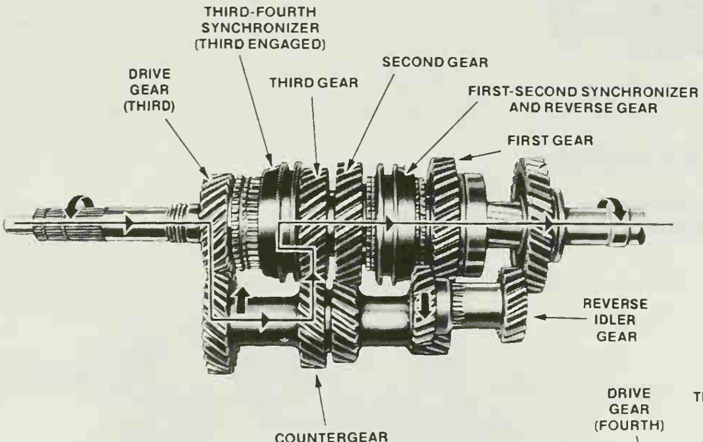


Figure 4-31. Power flow through a four-speed transmission in 3rd speed. (Chevrolet Motor Division of General Motors Corporation)

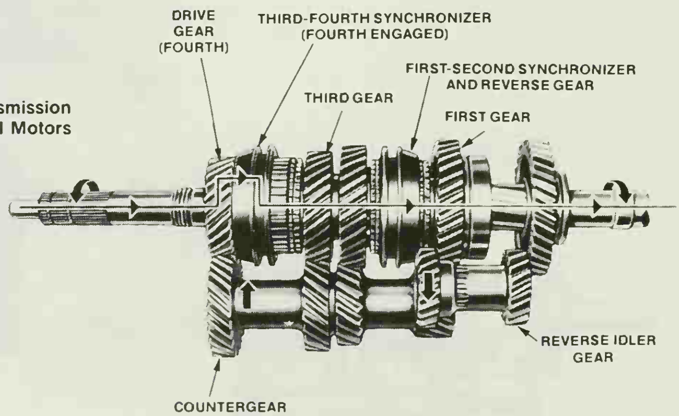


Figure 4-32. Power flow through a four-speed transmission in high gear or direct drive. (Chevrolet Motor Division of General Motors Corporation)

TRANSMISSION ACCESSORY CONNECTIONS

The manually operated transmission may be connected to several accessory systems on the automobile. One such accessory is the speedometer drive. A small gear housed on the rear of the transmission case meshes with a gear on the transmission output shaft. A cable connected to the gear in the housing drives the speedometer mechanism on the instrument panel.

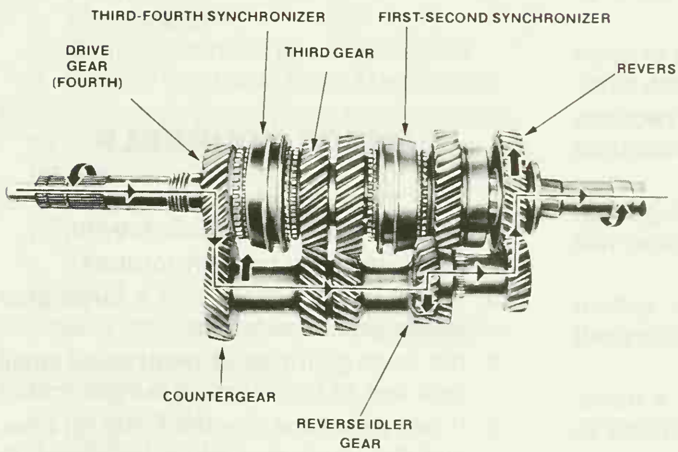


Figure 4-33. Power flow through a four-speed transmission in reverse gear. (Chevrolet Motor Division of General Motors Corporation)

A back-up light switch is sometimes worked by the shifting linkage on the transmission. When the driver shifts the transmission linkage into reverse, a switch is closed to light a set of back-up warning lights at the rear of the automobile.

The transmission may also be a part of the vehicle's emission control system. A transmission-controlled spark switch is installed in many late model transmissions. This switch is closed in all but high gear, grounding an electrical circuit in the emission control system. This has the effect of retarding the ignition.

NEW TERMS

Column shift linkage Shifting fork control linkage mounted to the driver's steering column.

Control linkage The floor or steering column linkage used by the driver to select the transmission gears.

Countershaft System of gears mounted in the transmission below the mainshaft.

Detent A ball or roller used to lock a component into position.

Floating gear A gear attached to a shaft other than the input or output shaft.

Floor shift linkage Shifting fork control linkage mounted to the floor next to the driver.

Four-speed transmission A transmission with four forward speeds or gear ratios.

Gear A wheel with teeth used to engage or mesh with another wheel with teeth to act as a lever.

Gear ratio The ratio of the number of teeth on two gears that are in mesh with each other.

Idler gear A gear that idles or floats between two other gears to provide a directional change in power flow.

Interlocks A system of detent plugs that prevents shifting forks from engaging two gears at one time.

Mainshaft A shaft that supports a system of gears mounted above the countershaft gear assembly.

Manually operated transmission A transmission that is shifted from one speed to another by the driver.

Reverse idler gear A small gear used to change the direction of output shaft rotation for reverse.

Shift fork, shifting fork Linkage-operated part used to operate transmission synchronizers.

Shift rail Shafts used to guide shift linkage movement.

Synchronizer A cone clutch device that works to synchronize the speed of gears and shafts so they can be meshed without clashing.

Three-speed transmission A transmission with three forward speeds or gear ratios.

Torque multiplication The increasing of the turning effort of the engine to get the vehicle moving.

CHECK YOURSELF

1. Why must the engine's torque be increased to get the vehicle moving?
2. How can a gear multiply torque?
3. When a small gear turns a large gear which gear turns faster?
4. If a large gear has 24 teeth and a small gear has 12 teeth what is the gear ratio?
5. If two gears are mounted with an idler, and the input gear turns clockwise, in what direction will the output gear turn?
6. Describe the power flow through a three-speed transmission in neutral.
7. Describe the power flow through a three-speed transmission in 1st speed.
8. Describe the power flow through a three-speed transmission in 2nd speed.
9. Describe the power flow through a three-speed transmission in direct drive.
10. Describe the power flow through a three-speed transmission in reverse.

CERTIFICATION PRACTICE

1. A three-speed transmission is in 2nd gear.
   Mechanic A says two synchronizers are locked.
   Mechanic B says one synchronizer is locked.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. An idler gear is used in:
   a. 1st speed
   b. 2nd speed
   c. 3rd speed
   d. Reverse
3. A three-speed transmission is in neutral.
   Mechanic A says no synchronizers are engaged.
   Mechanic B says no gears are rotating inside the transmission.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
4. When a large gear with 60 teeth is driven by a small gear with 20 teeth the gear ratio is:
   a. 60 to 20
   b. 6 to 2
   c. 3 to 1
   d. 6 to 1
5. When a large gear is driven by a small gear:
   a. Torque is multiplied
   b. Speed is reduced
   c. Both a and b
   d. Neither a nor b.
6. A four-speed transmission is in 4th gear.
   Mechanic A says two synchronizers are locked.
   Mechanic B says one synchronizer is locked.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B

DISCUSSION TOPICS AND ACTIVITIES

1. Use a cutaway shop transmission and trace the power flow through each speed.
2. Disassemble a shop synchronizer. Identify the parts and explain how the synchronizer works.

ANSWERS:

1. b, 2. d, 3. a, 4. c, 5. c, 6. b

Unit 5
Manual Transmission Service

When a manual transmission fails to shift properly or makes excessive noise, it may require service. Servicing a manual transmission involves performing regular preventive maintenance, troubleshooting to locate the source of a problem, and removing and replacing transmission components. This unit presents the procedures necessary to develop job competencies in each of these areas.

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

Preventive Maintenance

5-1 Identify a transmission model.
5-2 Drain and refill manual transmission lubricant.

Troubleshooting

5-3 Perform a road test and diagnose trouble.

Service

5-4 Adjust shifting linkage.
5-5 Replace an extension housing rear seal.
5-6 Remove a transmission.
5-7 Disassemble a manual transmission.
5-8 Clean and inspect transmission parts.
5-9 Reassemble a manual transmission.
5-10 Install a manual transmission.

JOB COMPETENCY 5-1 IDENTIFY A TRANSMISSION MODEL

Before a mechanic can perform specific preventive maintenance, troubleshooting, or service on a transmission, the transmission model must be identified. The manufacturer's shop or service manual provides detailed service procedure for each transmission model. Unless the mechanic knows what model transmission the vehicle has, this information will not be useful.

The first step in identifying a transmission is to locate the **vehicle identification number**, abbreviated VIN. This is the legal identification of the vehicle. It is stamped on a plate which is usually attached to the left top of the instrument panel and can be seen through the windshield from outside the car (Figure 5-1).

This number is used along with a **VIN decoding chart.** The VIN decoding chart is found in any manufacturer's shop manual for this model vehicle. The VIN decoding chart explains what each number and letter means on the vehicle identification number. A typical decoding chart is shown in Figure 5-2.

The first three characters of this vehicle identification number identify the transmission. The A indicates the vehicle is manufactured by American Motors Corporation. The number 6 means the vehicle was manufactured in 1976. The S indicates the transmission type. The decoding chart shows that the S indicates that the unit is a three-speed manual column shift.

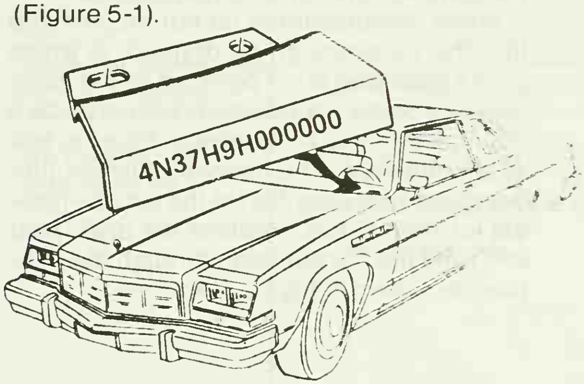
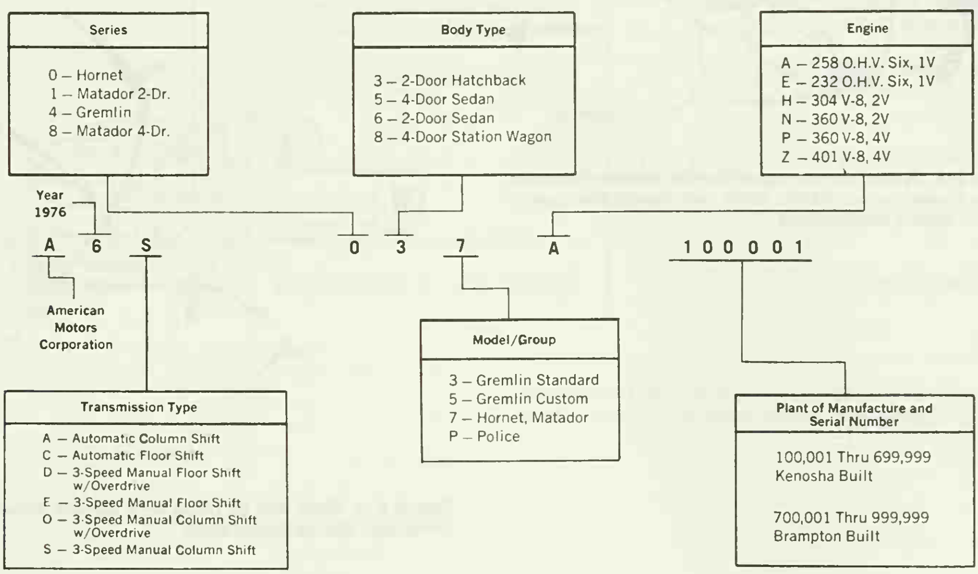


Figure 5-1. Vehicle identification number (VIN) location. (Buick Motor Division of General Motors Corporation)

Figure 5-2. Vehicle identification number decoding chart. (American Motors Corporation)



Another number and letter code is attached to a tag or stamped on the transmission. The typical location of the code is shown in Figure 5-3. This code identifies the transmission model such as 150T or 76MM. You may then find transmission service information by locating the service manual for that model and year. Then find the correct transmission model.

JOB COMPETENCY 5-2 DRAIN AND REFILL MANUAL TRANSMISSION LUBRICANT

A manual transmission is lubricated by gear lubricant inside a reservoir in the transmission case or housing. Rotating countershaft gears splash the lubricant up on all the gears, bushings, and bearings. The level of lubricant must be high enough so that countershaft gears can dip into the lubricant. If the lubricant level falls too low, there may be insufficient lubrication and damage to parts may result.

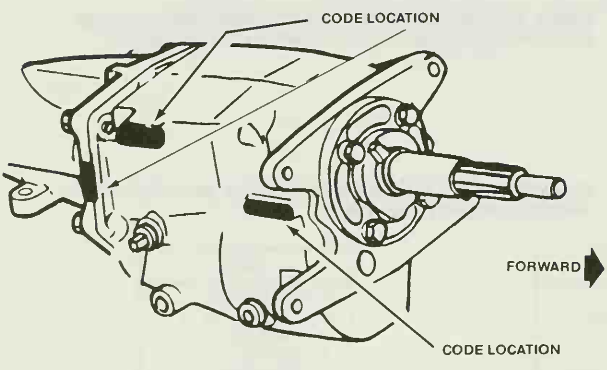


Figure 5-3. Typical vehicle identification number locations on the transmission. (GMC Truck and Coach Division of General Motors Corporation)

The lubricant may also become contaminated. Metal that wears off synchronizer rings, bushings, and gears can be circulated in the lubricant. If not removed, this metal can damage parts. For these reasons you must check the transmission lubricant for proper level and drain it at periodic intervals.

To check the lubricant level, raise the vehicle on a hoist. Make sure that the raised vehicle is level. Locate the **filler plug** in the side of the transmission case. Remove the plug. The lubricant should be at or just slightly below the level of the filler plug hole. If the level is low, add lubricant. Several different kinds of lubricants, from automatic transmission fluid to heavy gear lubricants, are used in different transmissions. Always follow the manufacturer's recommendations.

Some manufacturers do not recommend that the transmission be drained, in which case a **drain plug** is not provided on the transmission. Some manufacturers do provide a drain plug or use an extension housing bolt as a drain plug. The interval between lubricant drains is specified in the service manual for the vehicle. Replace the drain plug and refill the transmission through the filler plug, as shown in Figure 5-4.

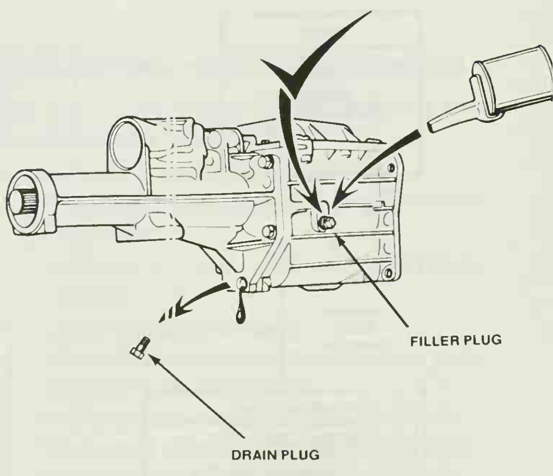


Figure 5-4. Drain and fill plugs on a manual transmission. (American Motors Corporation)

JOB COMPETENCY 5-3 PERFORM A ROAD TEST AND DIAGNOSE TROUBLE

The source of a problem inside a manual transmission may be determined by road-testing the vehicle. Drive the vehicle long enough to make sure the transmission is properly warmed up. Drive a test route in a quiet area where noises can be heard. Stop several times to shift the transmission.

Most manufacturers' shop manuals include a **diagnosis guide** like the one shown in Figure 5-5. These guides list the typical problem conditions and recommended corrections. Use the diagnosis guide after the road test to help isolate the problem.

Condition	Possible Cause	Correction
TRANSMISSION SHIFTS HARD	(1) Clutch adjustment incorrect	(1) Adjust clutch
	(2) Clutch linkage or cable binding	(2) Lubricate or repair as necessary
	(3) Shift rail binding	(3) Check for mispositioned selector arm roll pin, loose cover bolts, shift worn shift rail bores, worn shift rail, distorted oil seal, or extension housing not aligned with case. Repair as necessary
	(4) Internal bind in transmission caused by shift forks, selector plates, or synchronizer assemblies	(4) Remove, disassemble and inspect transmission. Replace worn or damaged components as necessary
	(5) Clutch housing misalignment	(5) Check runout at rear face of clutch housing. Correct runout
	(6) Incorrect lubricant	(6) Drain and refill transmission
GEAR CLASH WHEN SHIFTING FROM ONE GEAR TO ANOTHER	(1) Clutch adjustment incorrect	(1) Adjust Clutch
	(2) Clutch linkage or cable binding	(2) Lubricate or repair as necessary

Figure 5-5. A diagnosis guide is used to help find a transmission problem. (American Motors Corporation)

During the road test look for problems in the following areas: (1) The transmission shifts hard. (2) The gears clash when shifting from one forward gear to another. (3) The transmission is noisy. (4) The transmission jumps out of gear. (5) The transmission is locked in one gear and cannot be shifted out of that gear.

When a transmission shifts hard, the first area to check is the clutch. Incorrect clutch adjustment or binding clutch linkage can cause the problem. If the clutch operates satisfactorily, check the gearshift linkage; it may be incorrectly adjusted, bent or binding. There may be an internal bind in the transmission at the shift rails, interlocks, shifting forks, or synchronizer teeth.

Incorrect clutch adjustment or binding clutch linkage may also cause gearshift clash when you shift. If the gearshift linkage is incorrectly adjusted, bent, or binding, clash may result. Inside the transmission, damaged or worn transmission components such as shift forks, synchronizer, shift rails, and interlocks may cause gear clash. Excessive end play because of worn **thrust washers** is another cause of gearclash. When a transmission is noisy, first check the transmission lubricant. A low lubricant level, the wrong lubricant, or dirt or metal in the lubricant will cause noise. Loose housing bolts or gearshift linkage that is incorrectly adjusted, bent, or binding can also cause noise. Worn internal parts which can cause noise include: front and rear bearings, clutch and countershaft bearings, worn or damaged gear teeth or synchronizer components.

When a transmission jumps out of gear, first inspect the linkage. The linkage may be incorrectly adjusted, bent, or binding. A worn clutch pilot bearing may also be the cause. Inside the transmission look for worn synchronizer parts or worn tapered gear teeth. Worn shift forks, shift rails or detents, excessive end play in any of the gear assemblies, or worn rubber engine mounts can also cause this problem.

When a transmission is locked in one gear and cannot be shifted out of that gear, the problem is most likely in the shifting mechanism. Bent or binding gearshift linkage is the most probable cause. Worn shift rails, broken or worn shift forks or detents can lock the transmission in one gear. Broken gear teeth on the countershaft gear, clutch shaft, reverse idler or broken synchronizers can also lock up a transmission.

JOB COMPETENCY 5-4 ADJUST SHIFTING LINKAGE

Worn or improperly adjusted shifting linkage can cause any of the transmission problems just described. To check the linkage, raise the vehicle on a hoist. Visually inspect each shift control rod (Figure 5-6). Move each rod back and forth by hand to check for wear at the attachment points. Excessive movement will require new rods and fasteners. **Safety Note:** ***Make sure the vehicle hand brake is applied and the wheels are blocked so that it cannot move.*** Have a helper shift the transmission while you observe the linkage for any binding. Linkage that binds is worn excessively and must be replaced.

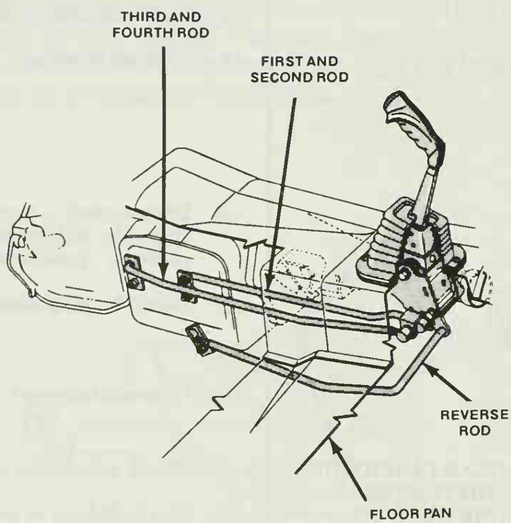


Figure 5-6. Check each shift control rod for looseness or binding. (Chrysler Corporation)

Linkage that is bent or distorted will not properly position the transmission synchronizer units. To adjust bent or new linkage you must lengthen or shorten control rods or control rod attachments to the correct specifications. In most cases you will need a manufacturer's **locating gage.** This gage is different for each vehicle. It has holes or tabs which, when installed on the linkage, show the mechanic which way to adjust the linkage. A locating gage is shown in Figure 5-7.

To make an adjustment, place the ignition switch in Off position. Raise the vehicle on a hoist. Loosen locknuts at swivels on the shift rods. Rods should pass freely through swivels. Set shift levers into neutral at the transmission. Move shift control lever in the neutral detent position, align control assembly levers, and insert the locating gage into the lever alignment slot. Tighten the locknuts at shift rod swivels and remove the locating gage. Shift the transmission control lever into reverse and place the ignition switch in Lock position. Loosen the locknut at the back drive control rod swivel, then pull down slightly on the rod to remove any slack in the column mechanism and tighten the clevis jam nut. Check the interlock control. The ignition key should move freely to and from the Lock position. Readjust the back drive control rod, if necessary. Check the transmission shift operation. Readjust shift controls, if necessary. Lower and remove the vehicle from the hoist.

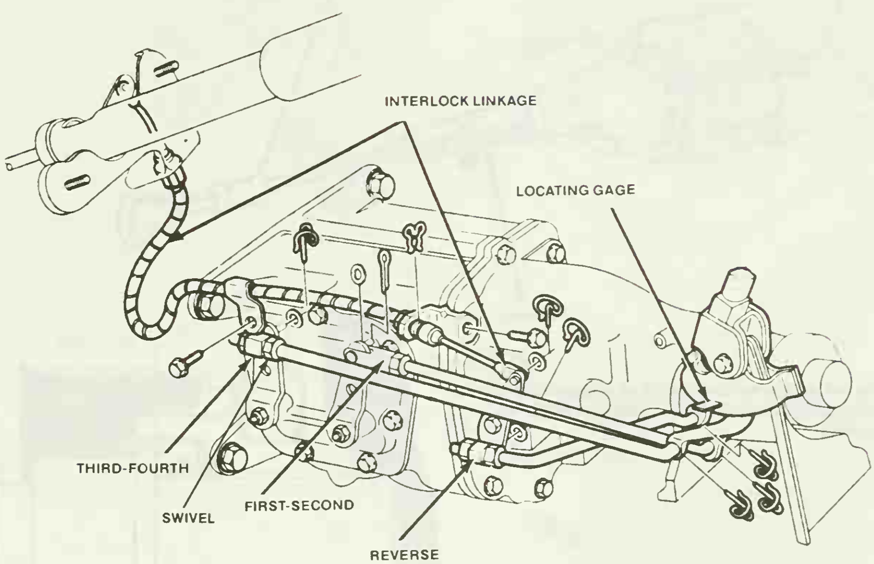


Figure 5-7. A locating gage is used to adjust shifting linkage. (Chevrolet Motor Division of General Motors Corporation)

JOB COMPETENCY 5-5
REPLACE AN EXTENSION HOUSING REAR SEAL

A lip-type seal is used around the output shaft in the transmission extension housing. This seal prevents lubricant from leaking out of the rear of the transmission. If this seal wears out, transmission lubricant will be visible around the end of the output shaft. This seal may be removed and replaced while the transmission is in the vehicle.

Lift the vehicle on a hoist. Make sure the vehicle is level. Place a drain pan under the extension housing. Disconnect the drive shaft at the rear universal joint. Mark both parts to reassemble in the same position. Carefully pull the shift yoke out of the transmission extension housing. Be careful not to scratch or nick the ground surface on the sliding spline yoke.

Remove the extension housing seal with a **seal puller.** A seal puller, Figure 5-8, has expanding fingers that fit behind the seal. The tool is connected to a slide hammer. Sliding the weight on the slide hammer pulls the tool and seal out of the extension housing.

To install a new seal, position the seal in the opening of the extension housing and drive it into the housing with a **seal driving tool** shown in Figure 5-9. Carefully guide the front universal joint yoke into the extension housing and on the output splines. Connect the drive shaft to the rear axle pinion shaft yoke, aligning the marks made at removal. Tighten the clamp screws to specifications. Fill the transmission to the level of the fill plug with recommended lubricant and lower the vehicle.

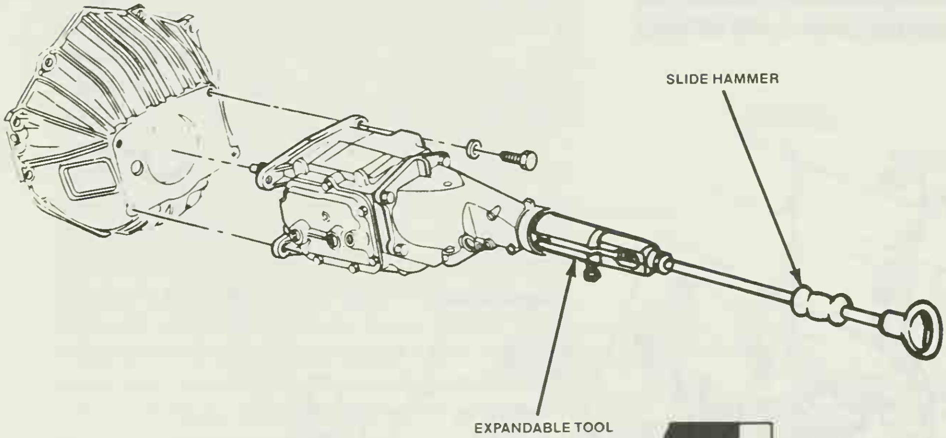


Figure 5-8. The old seal is removed with an expandable tool and a slide hammer. (Chevrolet Motor Division of General Motors Corporation)

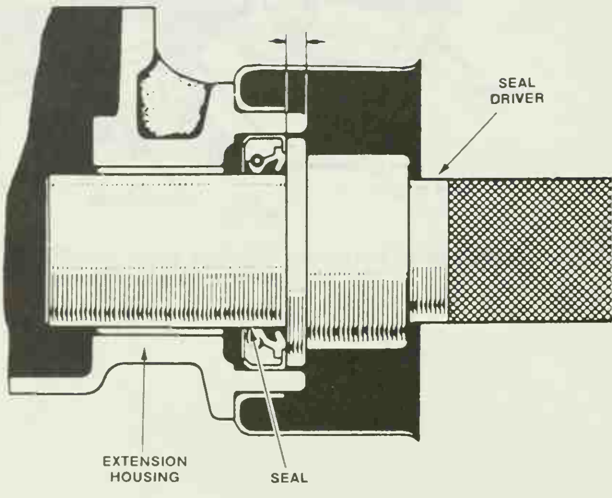


Figure 5-9. The new seal is installed by driving it into the extension housing with a seal driver.

JOB COMPETENCY 5-6
REMOVE A TRANSMISSION

If diagnosis procedures indicate a problem inside the transmission, it must be removed for service. **Safety Caution: Before raising the vehicle, disconnect the battery.** To remove the transmission, raise the vehicle on a suitable hoist and drain the transmission lubricant. Disconnect the speedometer cable and back-up light connector. Remove the shift controls from the transmission. On floor-shift vehicles, it will also be necessary to remove the shifter-assembly-to-shifter-support bolts and remove the shifter assembly from the transmission. If the shifter assembly replacement is not required, it may be left hanging from its floor seal while transmission is being removed.

Disconnect the drive shaft at the rear universal joint, marking parts to reinstall in same position. Carefully pull the shaft yoke out of transmission extension housing. Be careful not to scratch or nick the machined surface on the sliding spline yoke during removal and installation of the shaft assembly. On some models the exhaust systems will have to be partially removed for clearance. Install a jack or suitable support under the engine. Raise the engine slightly with the support fixture. Disconnect the extension housing from the removable center crossmember as shown in Figure 5-10. Support the transmission with a jack and remove the center crossmember.

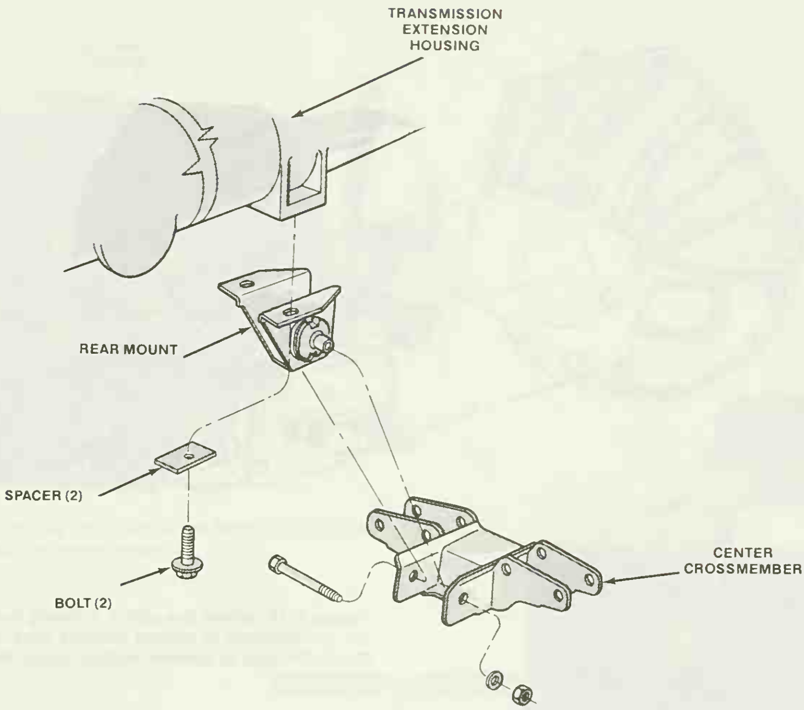


Figure 5-10. The center crossmember is removed on some vehicles to remove the transmission. (Chrysler Corporation)

Remove the transmission-to-clutch housing mounting bolts as shown in Figure 5-11. When removing the transmission, do not allow the weight of the transmission to hang on the clutch disc hub because the disc may become distorted, seriously affecting the clutch operation. Before lowering the transmission, slide the transmission toward the rear until the input shaft clears the clutch disc. Lower the transmission and remove it from under the vehicle.

Be sure to support the clutch release bearing and support assembly during removal of the transmission from the clutch housing. This will prevent the release bearing from falling out of the housing when the transmission is removed.

JOB COMPETENCY 5-7 DISASSEMBLE A MANUAL TRANSMISSION

Disassembly procedures are different for different transmissions, but the following procedures for a three-speed are typical. First, remove the top or side cover and gasket from the case. If the transmission is equipped with an overdrive, remove the overdrive from the transmission. Remove the back-up lamp switch extension housing or transmission adapter if the vehicle is equipped with overdrive. Remove any detent springs from detent bores in the case. Remove the upper detent plug from the detent bore with a magnet or tip the case on its side to allow the plug to fall out.

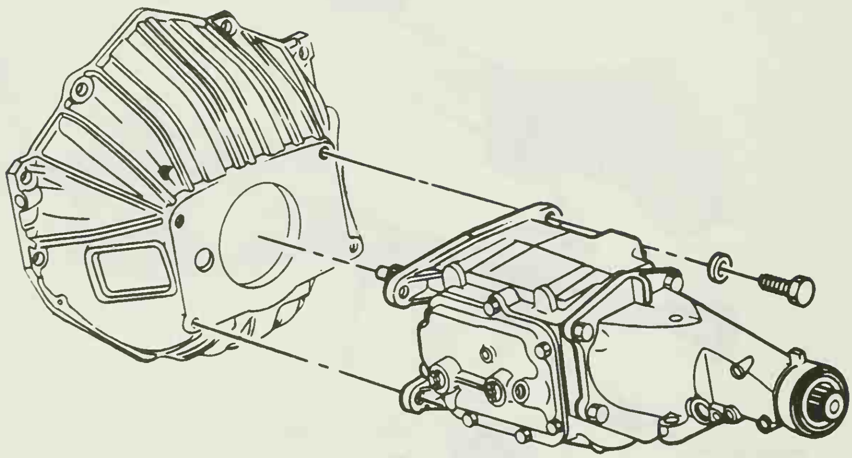


Figure 5-11. When the clutch housing bolts are removed, the transmission is moved straight back. (GMC Truck and Coach Division of General Motors Corporation)

On cars without overdrive, remove the extension housing and gasket. On cars with overdrive, remove the adapter and pump cam key from the transmission output shaft. Remove the speedometer drive-gear retaining snap ring from the output shaft and remove the gear and lock ball. Remove the large locating snap ring from the rear bearing and the smaller retaining snap ring from the output shaft. Punch an alignment mark in the front bearing cup and transmission case as shown in Figure 5-12 to ensure correct assembly. Remove the cup and gasket. Remove the large locating snap ring from the front bearing. Do not remove the smaller retaining snap ring from the clutch shaft. Remove the fill plug from the side of the case. Drive out the countershaft roll pin with a pin punch. Some roll pins are accessible through the fill plug hole.

To remove the countershaft, use a wood or brass shaft slightly smaller in diameter than the countershaft. This tool is called a **dummy shaft.** It is shorter than the countershaft so that the countergear assembly may be removed with the tool in place. Insert the dummy shaft into the bore at the front of the case. Tap lightly on the dummy shaft to drive the countershaft out of the rear of the case as shown in Figure 5-13. With the countershaft removed, allow the countershaft gear to lie at the bottom of the case.

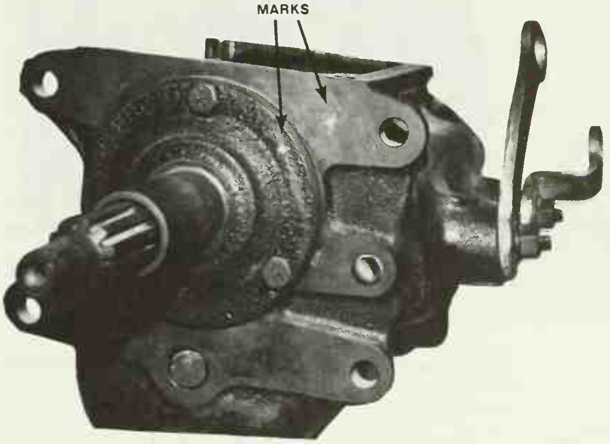


Figure 5-12. Punch marks are made on the front bearing cup to help in alignment on reassembly.

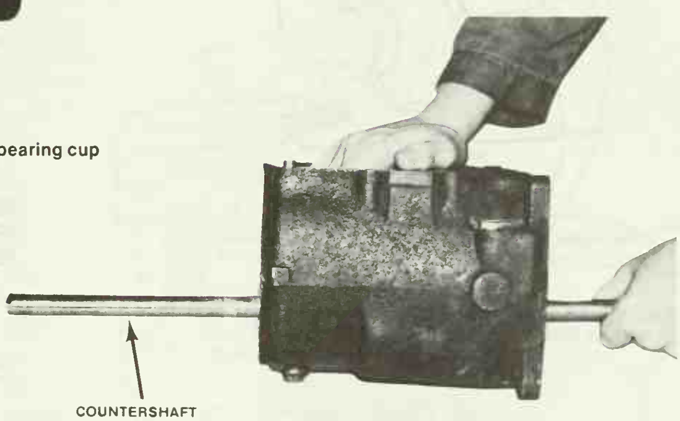


Figure 5-13. A dummy shaft is used to push out the countershaft.

Shift both synchronizers into neutral (centered) position. Remove the rear bearing from the output shaft and the case with a bearing puller as shown in Figure 5-14. Remove the setscrew from the 1st-reverse shift fork and slide the shift rail out of the rear of the case. Shift the 1st-reverse sleeve and gear all the way forward and rotate the 1st-reverse shift fork upward and out of the case.

Shift the 2nd-3rd shift fork, Figure 5-15, rearward into the 2nd gear position to gain access to the setscrew in the shifting fork. Remove the setscrew, rotate the shift rail 90° with pliers to clear the bottom detent plug and remove the interlock plug with magnet or tip the case on its side to let the plug to fall out.

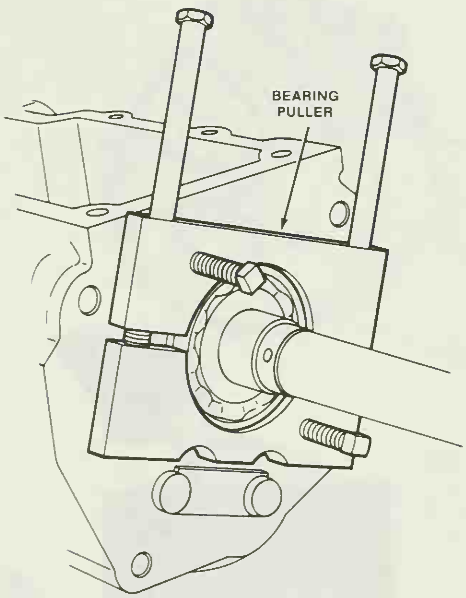


Figure 5-14. A puller is used to remove the rear bearing. (American Motors Corporation)

Remove the 2nd-3rd shift rail. Use a long, thin punch inserted through the access hole in the rear of the case to drive out the shift rail and expansion plug located in the shift rail bore at the front of case.

Remove the bottom detent plug and short detent spring from the detent bore in the case. Rotate the 2nd-3rd shift fork upward and out of the case. Remove the clutch shaft, front bearing, and synchronizer ring as an assembly with the pulling tool shown in Figure 5-16. Retrieve any of the clutch shaft roller bearings that may fall into the case after the output shaft has been removed.

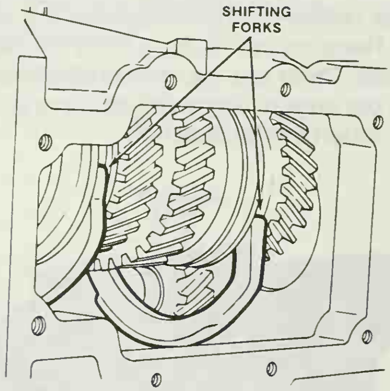


Figure 5-15. Shifting fork removal. (American Motors Corporation)

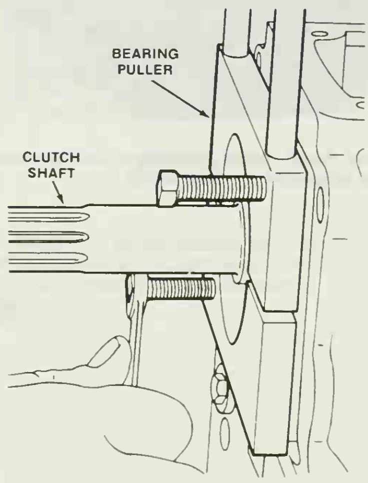


Figure 5-16. Clutch shaft is removed with a puller. (American Motors Corporation)

Remove the output shaft assembly. Tilt the spline end of the shaft downward and lift the gear end upward and out of the case as shown in Figure 5-17. First and reverse sleeve and gear must pass through the notch at the right rear end of the case.

Remove the countershaft gear with the dummy shaft in place. Remove both shift fork shafts and any clutch shaft roller bearings or countershaft gear needle bearings that may have fallen into the case during shaft removal.

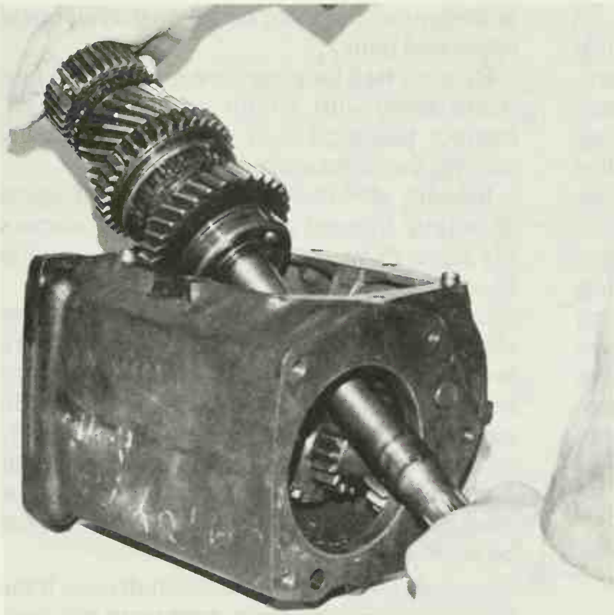


Figure 5-17. Removing the output or mainshaft assembly.

Remove the dummy shaft tool from the countershaft gear. Remove the bearing retainers and needle bearings from each end of the gear. Remove the reverse idler gear and thrust washers by tapping the shaft with a brass drift and hammer until end of the idler gear shaft with the roll pin clears the counterbore in the rear of case as shown in Figure 5-18. Remove the shaft.

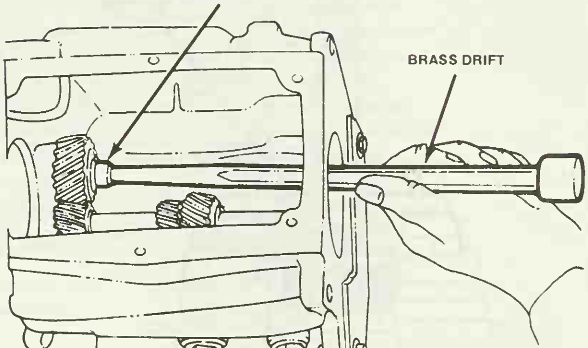


Figure 5-18. A brass drift is used to drive out the reverse idler shaft. (American Motors Corporation)

Remove the snap ring from the front of the output shaft and remove 2nd-3rd synchronizer assembly and 2nd gear. Punch alignment marks on the hub and sleeve to ensure correct assembly. Observe the position of the insert springs and inserts during removal, for correct assembly later. Remove the insert springs from the 2nd-3rd synchronizer. Remove the three T-shaped inserts and separate the sleeve from the synchronizer hub. Remove the snap ring and tabbed thrust washer from the shaft and remove the 1st gear and synchronizing ring.

Remove the 1st-reverse hub retaining snap ring. Observe the position of inserts and spring before removal for correct assembly. Remove the sleeve and gear, insert spring, and three inserts from the hub. Remove the hub from the output shaft using an arbor press. Do not attempt to hammer the press-fit hub from shaft. Hammer blows will damage the hub shaft. Remove the front bearing retaining snap ring. Press the front bearing from the shaft with an **arbor press** as shown in Figure 5-19. Do not attempt to drive the bearing from the shaft with a hammer. Hammer blows will damage the bearing and shaft.

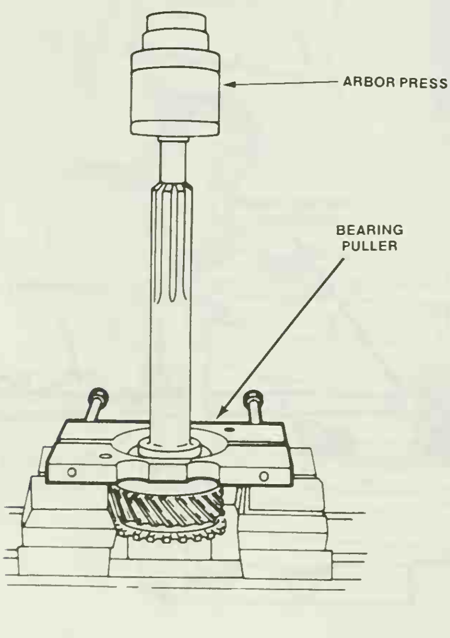


Figure 5-19. The front bearing is removed on an arbor press. (American Motors Corporation)

JOB COMPETENCY 5-8 CLEAN AND INSPECT TRANSMISSION PARTS

Clean the transmission case thoroughly with a suitable solvent, and let it dry. Inspect the case for cracks and stripped threads in the bolt holes. Check the machined mating surfaces for burrs or nicks. The front mating surface should be smooth; if any burrs are present, dress them off with a fine file.

Wash ball bearings with a clean solvent and let them dry. Do not spin bearings with air pressure. Spinning bearings may damage races and balls.

Be sure ball bearings are clean, then lubricate them with a light-grade engine oil. Inspect bearings for roughness by slowly turning the outer race by hand.

Inspect all bearing rollers for flat spots or pitting. Inspect all bearing roller spacers for signs of wear or pits. Install new parts as required.

Inspect gear teeth on the synchronizer clutch gears and synchronizer rings. If there is evidence of chipping or excessively worn teeth, install new parts at reassembly. Be sure the synchronizer sleeve slides easily on the synchronizer hub. Inspect all gear teeth for chipped or broken teeth, or signs of excessive wear. Small nicks or burrs must be stoned off.

Inspect teeth on the clutch shaft gear. If the gear is excessively worn, broken or chipped, install a new clutch shaft. If the oil seal contact area on the clutch shaft is pitted, rusted, or scratched, a new shaft is recommended for best seal life.

Test interlocks for free movement in the bore of the shift housing. Examine the detent balls for signs of pitting. If any detents show signs of too much wear, install a new part. Inspect shift forks for wear on the shanks and pads.

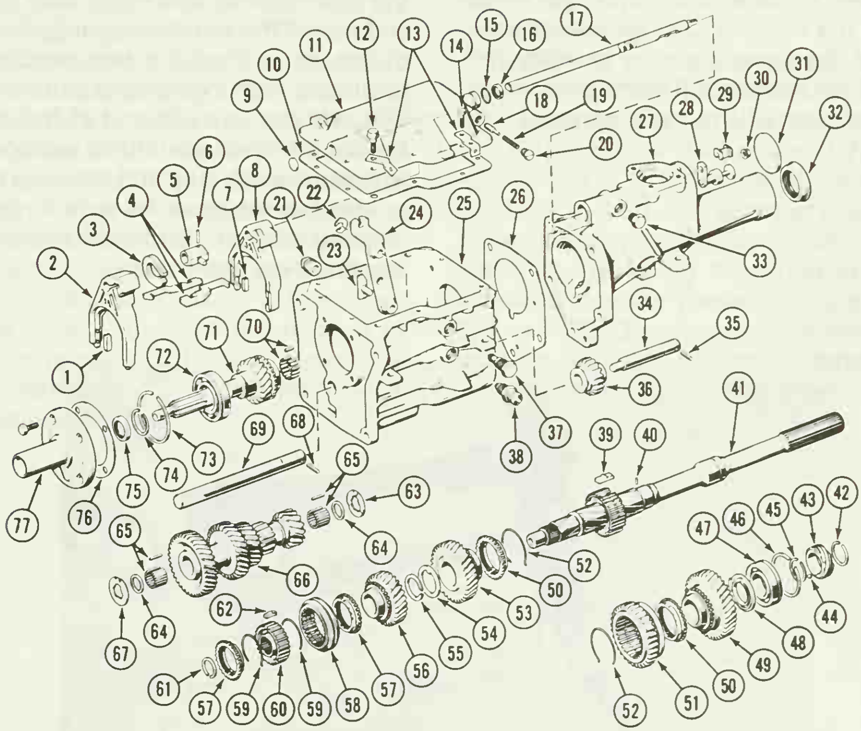
Inspect the mainshaft gear and bearing mating surfaces. If the gear contact surfaces show signs of pitting or are worn too much, install a new mainshaft.

Inspect the snap ring grooves for burred edges. If the grooves are rough or burred, smooth with a fine file or crocus cloth. Inspect the synchronizer clutch gear splines on the

shaft for burrs. Replace worn parts with new ones as required.

JOB COMPETENCY 5-9 REASSEMBLE A MANUAL TRANSMISSION

To reassemble a transmission follow the reassembly procedure in the manufacturer's service manual. An exploded view of a transmission similar to that shown in Figure 5-20 also makes a helpful reassembly guide. The following are general procedures.



1. THIRD – FOURTH SHIFT FORK INSERT
2. THIRD – FOURTH SHIFT FORK
3. SELECTOR INTERLOCK PLATE
4. SELECTOR ARM PLATE (2)
5. SELECTOR ARM
6. SELECTOR ARM ROLL PIN
7. FIRST – SECOND SHIFT FORK INSERT
8. FIRST – SECOND SHIFT FORK
9. SHIFT RAIL PLUG
10. TRANSMISSION COVER GASKET
11. TRANSMISSION COVER
12. TRANSMISSION COVER DOWEL BOLT (2)
13. CLIP
14. TRANSMISSION COVER BOLT (8)
15. SHIFT RAIL O-RING SEAL
16. SHIFT RAIL OIL SEAL
17. SHIFT RAIL
18. DETENT PLUNGER
19. DETENT SPRING
20. DETENT PLUG
21. FILL PLUG
22. REVERSE LEVER PIVOT BOLT C-CLIP
23. REVERSE LEVER FORK
24. REVERSE LEVER
25. TRANSMISSION CASE
26. EXTENSION HOUSING GASKET
27. EXTENSION HOUSING
28. OFFSET LEVER
29. OFFSET LEVER INSERT
30. OFFSET LEVER RETAINING NUT
31. ACCESS PLUG
32. EXTENSION HOUSING OIL SEAL
33. THREADED PLUG
34. REVERSE IDLER SHAFT
35. REVERSE IDLER SHAFT ROLL PIN
36. REVERSE IDLER GEAR
37. REVERSE LEVER PIVOT BOLT
38. BACKUP LAMP SWITCH
39. FIRST – SECOND SYNCHRONIZER INSERT (3)
40. FIRST GEAR ROLL PIN
41. OUTPUT SHAFT AND HUB ASSEMBLY
42. SPEEDOMETER GEAR SNAP RING
43. SPEEDOMETER GEAR
44. SPEEDOMETER GEAR DRIVE BALL
45. REAR BEARING RETAINING SNAP RING
46. REAR BEARING LOCATING SNAP RING
47. REAR BEARING
48. FIRST GEAR THRUST WASHER
49. FIRST GEAR
50. FIRST – SECOND SYNCHRONIZER BLOCKING RING (2)
51. FIRST – REVERSE SLEEVE AND GEAR
52. FIRST – SECOND SYNCHRONIZER INSERT SPRING (2)
53. SECOND GEAR
54. SECOND GEAR THRUST WASHER (TABBED)
55. SECOND GEAR SNAP RING
56. THIRD GEAR
57. THIRD – FOURTH SYNCHRONIZER BLOCKING RING (2)
58. THIRD – FOURTH SYNCHRONIZER SLEEVE
59. THIRD – FOURTH SYNCHRONIZER INSERT SPRING (2)
60. THIRD – FOURTH SYNCHRONIZER HUB
61. OUTPUT SHAFT SNAP RING
62. THIRD – FOURTH SYNCHRONIZER INSERT (3)
63. COUNTERSHAFT GEAR REAR THRUST WASHER (METAL)
64. COUNTERSHAFT NEEDLE BEARING RETAINER (2)
65. COUNTERSHAFT NEEDLE BEARING (50)
66. COUNTERSHAFT GEAR
67. COUNTERSHAFT GEAR FRONT THRUST WASHER (PLASTIC)
68. COUNTERSHAFT ROLL PIN
69. COUNTERSHAFT
70. CLUTCH SHAFT ROLLER BEARINGS (15)
71. CLUTCH SHAFT
72. FRONT BEARING
73. FRONT BEARING LOCATING SNAP RING
74. FRONT BEARING RETAINING SNAP RING
75. FRONT BEARING CAP OIL SEAL
76. FRONT BEARING CAP GASKET
77. FRONT BEARING CAP

Figure 5-20. An exploded view of the transmission is helpful in reassembly. (American Motors Corporation)

Lubricate the reverse idler gearshaft and bushings (press-fit in gear) with transmission lubricant. Coat the transmission case reverse idler gear thrust washer surfaces with petroleum jelly and position the washers in the case. Be sure to engage the locating tabs on the thrust washers in the locating slots in the case. Install the reverse idler gear. Align the gear bore, thrust washers, and case bores and install the reverse idler gearshaft from the rear of the case. Be sure to align and set the roll pin in the shaft into the counterbore in the rear of the case as shown in Figure 5-21.

Measure the reverse idler gear end play by inserting a feeler gage between the thrust washer and gear. End play must be correct when compared to specifications. If the end play is more or less than specifications, thicker or thinner thrust washers are required.

Coat the needle bearing bores in the countershaft gear with petroleum jelly. Insert the dummy shaft tool in the bore of the gear and install the needle bearings in each end of the gear. Coat the two needle bearing retainers with petroleum jelly and install one retainer in each end of the gear. Coat the countershaft gear thrust washer surfaces with petroleum jelly and position the thrust washers in the case. Be sure to engage the locating tabs on the thrust washers in the locating slots in the case.

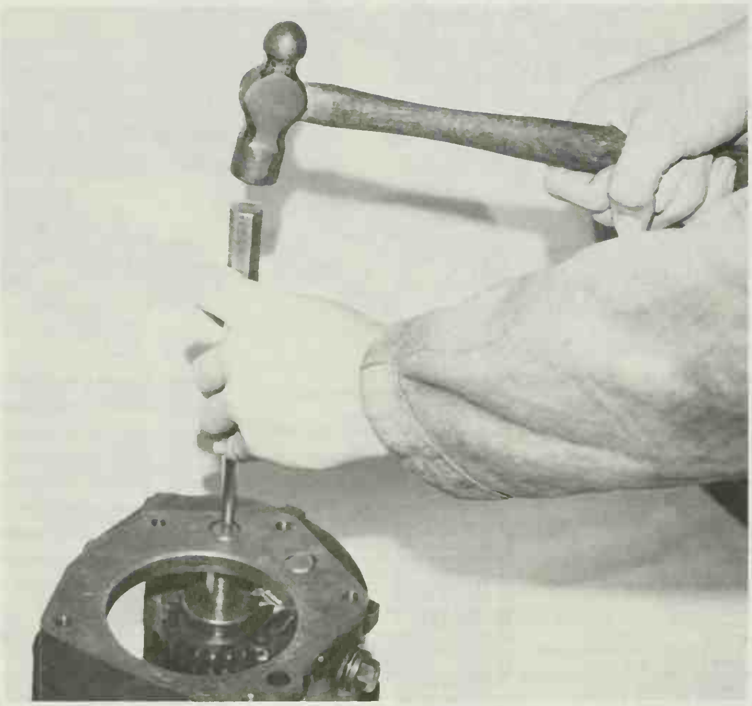


Figure 5-21. Reverse idler gearshaft installation.

Insert the countershaft into the bore at the rear of the case just far enough to hold the rear thrust washer in position. This will prevent the thrust washer from being displaced when the countershaft gear is installed. Install the countershaft gear in the case. Align the gear bore, thrust washers, and bores in the case, and install the countershaft.

Measure the countershaft end play by inserting a feeler gage between the washer and the countershaft gear. The end play should be correct according to specifications. If the end play is excessive, remove the gear and replace the thrust washers. When end play is correct, reinstall the dummy shaft in the countershaft gear and allow the gear to remain at the bottom of the case. Leave the countershaft in the rear case bore to hold the rear thrust washer in place. The countershaft gear must remain at the bottom of the case to provide sufficient clearance for the installation of output and clutch shaft assemblies.

Place the case in a level position, then insert the short lower detent spring in the detent bore in the case. Allow the spring to drop into place at the bottom of the 2nd-3rd shift rail bore. Insert the lower detent plug in the detent bore in the case. Allow the plug to drop into place on top of the detent spring. If the plug becomes cocked in the bore, reposition it with a small magnet and screwdriver.

Coat all the splines and machined surfaces on the output shaft with transmission lubricant and start the 1st-reverse synchronizer hub on the output shaft splines by hand. The end of the hub with slots should face the front of the shaft. Use an arbor press to complete the hub installation on the shaft and install the retaining snap ring in the most rearward groove. These parts are shown in Figure 5-22. Do not attempt to drive the hub onto the shaft with a hammer. Hammer blows will damage the hub and splines.

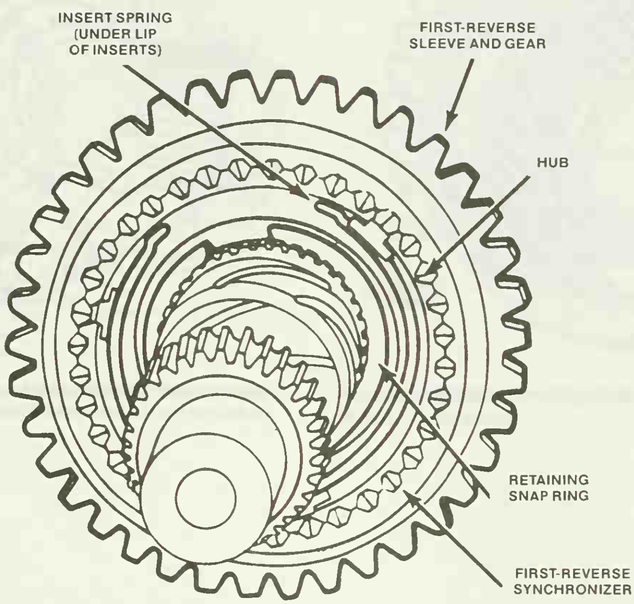


Figure 5-22. Snap ring and insert spring in position in first-reverse hub. (American Motors Corporation)

Coat splines on the 1st-reverse hub with transmission fluid and install the 1st-reverse sleeve and gear halfway onto hub with the gear end of the sleeve facing the rear of the shaft. Align the sleeve to the hub using marks made during disassembly.

Install the insert spring in the 1st-reverse hub. Make sure the spring is bottomed in the hub and covers all three insert slots. Position the three T-shaped inserts in the hub with small ends in the hub slots and large ends inside the hub as shown in Figure 5-23. Push the inserts fully into the hub so they seat on the insert spring, then slide the 1st-reverse sleeve and gear over the inserts until the inserts engage in the sleeve.

Coat the bore and synchronizer ring surface of 1st gear with transmission fluid and place the 1st gear synchronizer ring on the tapered surface of the gear. Install the gear on the output shaft. Rotate the gear until the notches in the synchronizer ring line up with the tapered surface of gear. Install the gear on the output shaft. Rotate the gear until the notches in the synchronizer ring engage the inserts in the 1st-reverse hub, then install the tabbed thrust washer and retaining snap ring on the output shaft as shown in Figure 5-24.

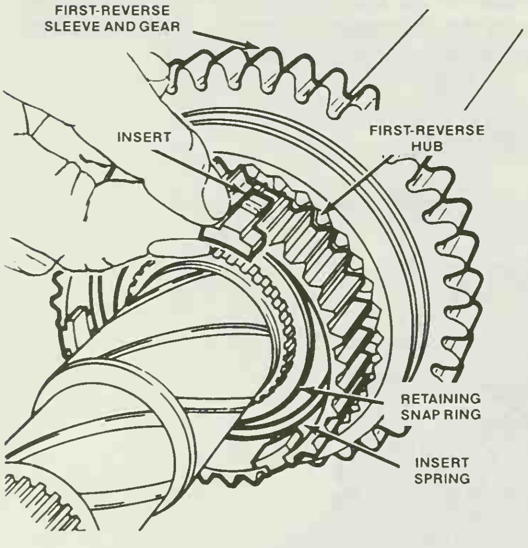


Figure 5-23. Installing inserts in first-reverse hub. (American Motors Corporation)

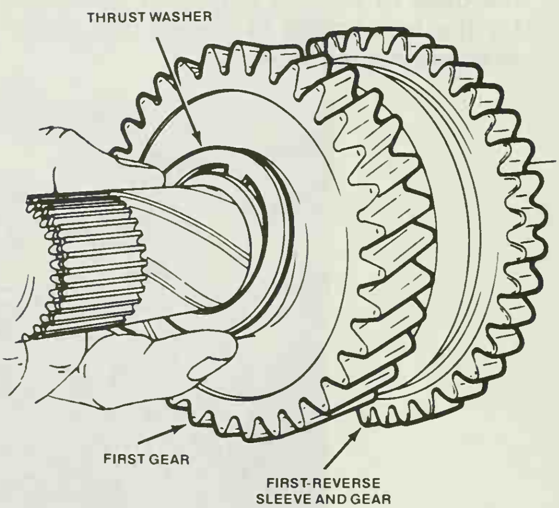


Figure 5-24. Installing first gear thrust washer on mainshaft or output shaft. (American Motors Corporation)

Coat the bore and synchronizing ring surface of 2nd gear with transmission fluid and place the 2nd gear synchronizing ring on the tapered surface of the gear. Install the 2nd gear on the output shaft with the tapered surface of the gear facing the front of the output shaft as shown in Figure 5-25.

Install one insert spring into the 2nd-3rd hub and be sure the spring covers all three insert slots in the hub. Align the 2nd-3rd sleeve to the hub, using marks made during disassembly, and start the sleeve onto the hub. Place three inserts into hub slots and on top of the insert spring. Then push the sleeve fully onto the hub to engage the inserts in the sleeve as shown in Figure 5-26. Install the remaining insert spring in exactly the same position as the first spring. Ends of both springs must cover the same slots in the hub and must not be staggered. Inserts have a small lip on each end. When correctly installed, this lip will fit over the insert spring.

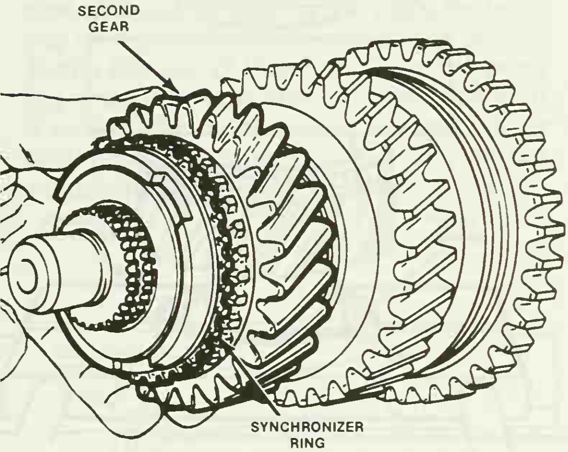


Figure 5-25. Installing second gear on mainshaft or output shaft. (American Motors Corporation)

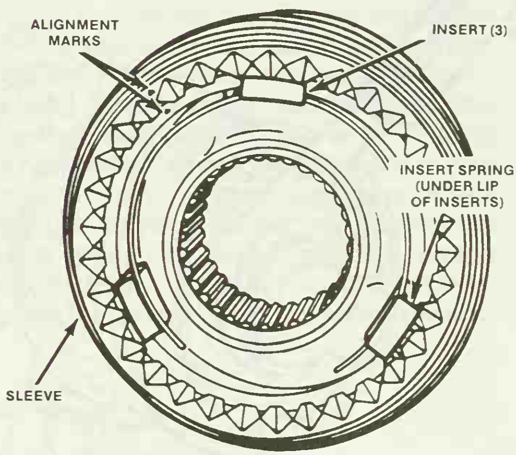


Figure 5-26. Second-third synchronizer assembly. (American Motors Corporation)

Install the 2nd-3rd synchronizer assembly on the output shaft. Rotate the 2nd gear until notches in the synchronizing ring engage inserts in the 2nd-3rd synchronizer assembly. Install the retaining snap ring on the output shaft and measure the end play between the snap ring and the 2nd-3rd synchronizer hub with a feeler gage as shown in Figure 5-27. The end play should be set to specifications. If the end play is not correct according to specifications, replace the thrust washer and all snap rings on the output shaft assembly.

Install the output shaft assembly in the case. Center the synchronizer sleeves so that the transmission is in neutral gear. Install the shifting forks, detent plugs, and shift rails. Press the front bearing onto the clutch shaft as shown in Figure 5-28. Install the retaining snap ring on the shaft and install the large locating snap ring in the bearing groove. Coat the bore of the clutch shaft assembly with petroleum jelly and install roller bearings in the clutch shaft bore. Do not use chassis grease or a similar heavy grease in the clutch shaft bore. Heavy grease will plug the lubricant holes in the shaft and prevent proper lubrication of the roller bearings.

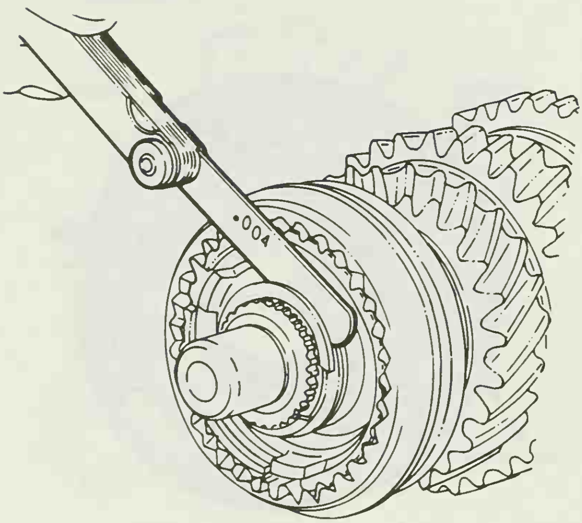


Figure 5-27. Measuring mainshaft or ouput shaft end play. (American Motors Corporation)

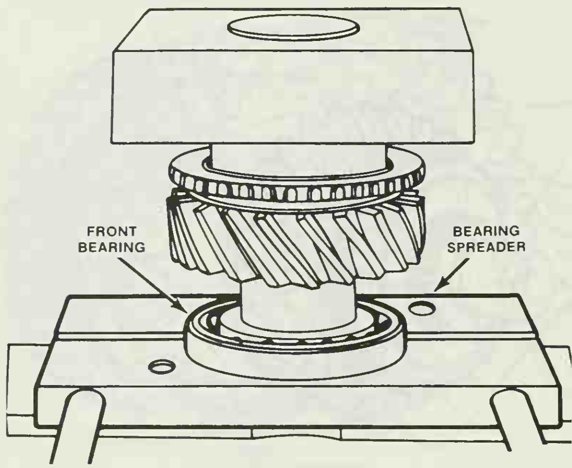


Figure 5-28. Pressing on the front bearing. (American Motors Corporation)

Coat the synchronizing ring surface of the clutch shaft with transmission lubricant and position the ring on the shaft. Support the output shaft assembly and insert the clutch shaft through the front bearing bore in the case. Seat the output shaft pilot in the roller bearings of the clutch shaft, and tap the bearing into position in the case with a plastic hammer.

Apply a thin film of sealer to the front bearing cup gasket and position the gasket on the case. Be sure any cutout in the gasket is aligned with the oil return hole in the case. Remove the bearing cup oil seal with a screwdriver. Install a new oil seal with a seal driver.

Install the front bearing cup and tighten the attaching bolts with a torque wrench to specifications. Be sure to align the front bearing cup to the transmission case with alignment marks made during disassembly. Install the large locating snap ring on the rear output shaft bearing and place the bearing on the shaft with the snap ring groove facing the rear of the shaft. Drive the bearing onto the shaft and into the case with a length of pipe as shown in Figure 5-29 and install the retaining snap ring on the output shaft.

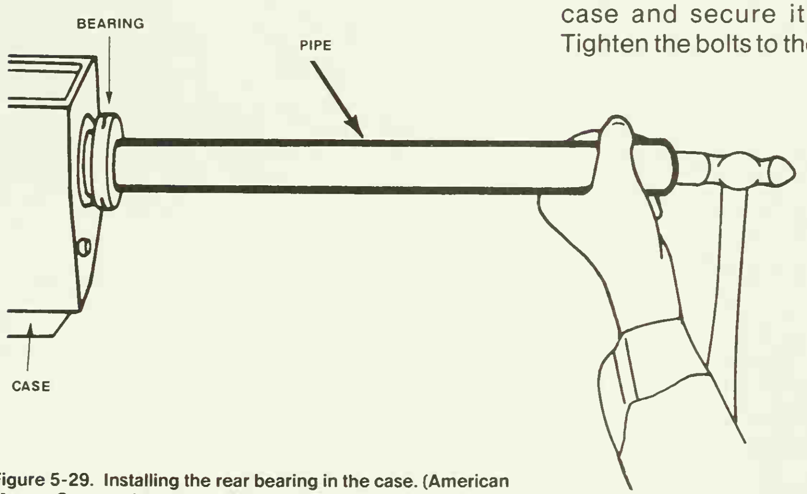


Figure 5-29. Installing the rear bearing in the case. (American Motors Corporation)

Install the speedometer drive-gear lock ball in the shaft. Slide the gear onto the shaft and over the lock ball. Install the retaining snap ring. Align the bore in the countershaft gear with the countershaft and front thrust washer. Then start the countershaft into the countershaft gear. Before the countershaft is completely installed, make sure that the roll pin hole in the countershaft is aligned with holes in the case. When the holes are aligned, tap the countershaft into place, remove the dummy shaft, and install the roll pin into the case.

Apply sealer to the extension housing or transmission adapter gasket and position the gasket on the case. Remove the extension housing oil seal with a screwdriver. Install a new seal using a seal driving tool. Apply sealer to extension housing-to-case bolts and install extension housing or transmission adapter if equipped with overdrive. Tighten bolts to recommended torque. Install all electrical switches removed during disassembly.

Install the transmission fill plug and tighten to the recommended torque. Place the transmission in gear. Pour the recommended capacity of transmission lubricant over the gear train and into the case while rotating the clutch shaft. Check the operation of new transmission in all gear positions. Apply sealer to the cover gasket and position the gasket on the case. Install the cover on the case and secure it with attaching bolts. Tighten the bolts to the recommended torque.

JOB COMPETENCY 5-10
INSTALL A MANUAL TRANSMISSION

With the transmission on a suitable jack, slide the assembly under the vehicle. Raise the transmission until the input shaft is centered in the clutch housing bore. Roll the transmission slowly forward until the input shaft enters the clutch disc. With the transmission in gear, turn the output shaft until the splines are aligned, then push the transmission forward until it is seated against the clutch housing. Some maneuvering may be required to align the transmission input shaft splines and the clutch-driven plate splines. Do not allow the transmission to "hang" after the input shaft has entered the clutch disc.

Install transmission-to-clutch-housing bolts and tighten them to recommended torque. Align crossmember bolt holes, then install attaching bolts. Remove the jack. Tighten to the recommended torque.

If removed, connect exhaust pipes to manifolds. Connect speedometer cable and back-up lamp switch wires. Carefully guide front universal joint yoke into the extension housing and onto the mainshaft splines. Connect the driveshaft to the rear axle pinion yoke, aligning the marks made at removal.

Connect the shift control rods to the floor or column shift unit. Check transmission for proper shifting. Check and correct the lubricant level if necessary. Lower the vehicle. Remove any engine supports. Connect the battery. Road-test the vehicle to make sure the transmission shifts smoothly and operates quietly.

NEW TERMS

Arbor press Hydraulic tool used to push or pull on a part for disassembly or reassembly.

Diagnosis guide Chart provided by a manufacturer, listing problems and possible causes.

Drain plug Drain plug used to remove lubricant from a transmission.

Dummy shaft Shaft installed in place of countergear shaft to hold bearings in place.

Filler plug Plug in side of the transmission, used to fill the unit with lubricant.

Locating gage Tool used to adjust shift linkage.

Seal driver Tool used to drive new seal in place.

Seal puller Tool used to pull old seal out of a housing or case.

Thrust washer Washer used to take up free play when parts are under a load.

Vehicle identification number (VIN) Number and letter code used to identify the vehicle and its component parts.

VIN decoding chart Chart used to interpret the vehicle identification number.

JOB COMPETENCY TEST

1. Where is the vehicle identification number located on an automobile?
2. How is the vehicle identification number used to identify a transmission?
3. How is the lubricant in a transmission drained and refilled?
4. What is a transmission diagnosis guide?
5. What problems can be caused by worn or improperly adjusted shift linkage?
6. Describe how to remove and replace an extension housing seal.
7. Why should a transmission not be allowed to hang on the clutch disc when it is being removed?
8. What is a dummy shaft and how is it used?
9. How are transmission bearings inspected?
10. How is countergear shaft end play measured and corrected?

CERTIFICATION PRACTICE

1. Mechanic A says a transmission can be identified by the vehicle identification number on the dash.
   Mechanic B says a transmission can be identified by a number stamped on the transmission.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor B
2. A transmission that shifts hard may have a problem:
   a. With the clutch
   b. With the gearshift linkage
   c. Both a and b
   d. Neither a nor b
3. Mechanic A says the transmission must be removed to replace an extension housing seal.
   Mechanic B says an extension housing seal may be replaced with the transmission in the vehicle.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
4. The countergear shaft is removed with a(n):
   a. Arbor press
   b. Bearing driver
   c. Dummy shaft
   d. None of the above
5. Mechanic A says that end play on a countergear assembly is corrected with selective thrust washers.
   Mechanic B says that end play on a countergear assembly is corrected with selective snap rings.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B

ANSWERS:

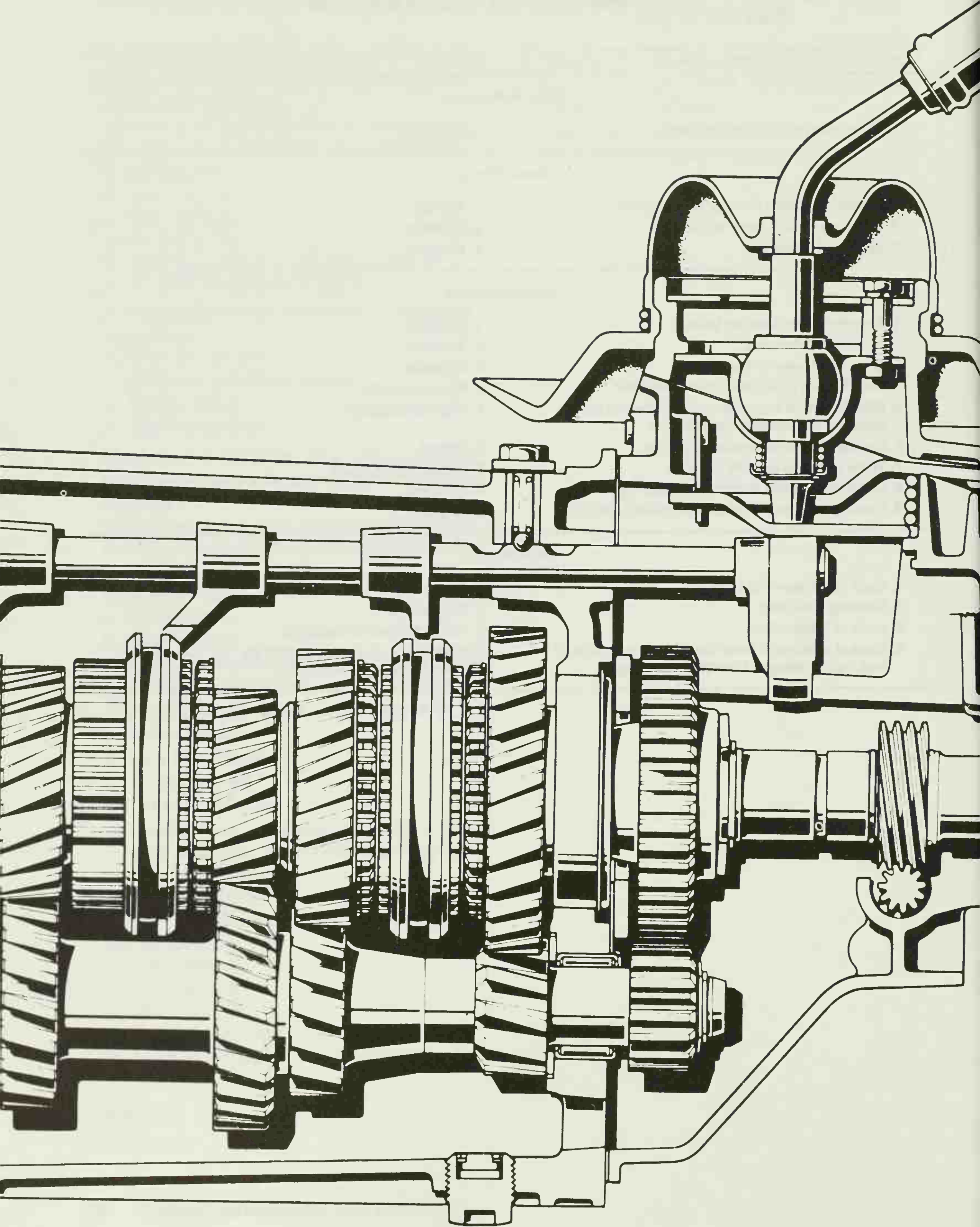
1.c, 2.c, 3.b, 4.c, 5.a

DISCUSSION TOPICS AND ACTIVITIES

1. Take a vehicle with a transmission problem on a test drive. Use a diagnosis guide to locate the problem.
2. Inspect the parts on a shop transmission and decide which ones require replacement.

TRANSMISSION TECH CHECK

Possible Cause	Service
	Locks in two gears
1. Worn detent components	1. Replace
	Hand shifting
1. Improper clutch linkage adjustment	1. Adjust
2. Synchro-clutch wear or failure	2. Replace
3. Incorrect lubricant	3. Replace
	Jumps out of gear
1. Synchronizer wear or failure	1. Replace
2. Incorrect lubricant	2. Replace
3. Gear teeth worn or tapered	3. Replace
4. Insufficient inter-lock spring tension	4. Replace parts
5. Misaligned or loose clutch housing or clutch housing to transmission adapter	5. Align and tighten
6. Excessive transmission end play	6. Adjust
7. Worn or loose engine mounts	7. Tighten or replace
8. Damaged clutch shaft roller bearings	8. Replace
9. Damaged or worn crankshaft pilot bushing	9. Replace
	Noise in gear
1. Gear teeth worn or broken	1. Replace gears
2. Shifting fork bent	2. Replace fork
3. Lack of lubrication	3. Add lubricant as required
4. Gasket leaking at front bearing or cap oil seal leaking; oil slinger broken or missing	4. Inspect oil seal, gasket, and oil slinger; replace as required



Unit 6
Overdrive Transmission

The transmissions we have described up to this point provide a direct drive in high gear. That is, the input shaft is connected directly to the output shaft at a 1 to 1 ratio. Many manufacturers offer an **overdrive transmission.** An overdrive transmission provides an additional speed with a ratio higher than 1 to 1. A four-speed overdrive might have gear ratios of: first, 3.09 to 1; second, 1.67 to 1; third, 1 to 1; overdrive, .71 to 1.

When the transmission is in the overdrive gear, the engine and transmission input shaft are turning more slowly than the output shaft. This means that for any given road speed the engine is turning more slowly than it would be in direct drive, and this can result in significant fuel savings, reduced engine wear, and less engine noise.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Explain how an overdrive is achieved by gears inside a transmission.
2. Identify the parts and explain the operation of a planetary gear system.
3. Describe the power flow through an overdrive in engagement and disengagement.
4. Describe the operation of an overdrive hydraulic system.
5. Explain the operation of an overdrive electrical system.

OVERDRIVE GEARS INSIDE THE TRANSMISSION

An overdrive speed may be achieved by equipping the transmission with a countershaft and mainshaft gear with the appropriate number of teeth to provide an overdrive ratio. The overdrive may be a 4th- 5th- or even a 6th-speed ratio. An overdrive four-speed

transmission is shown in Figure 6-1. The gear on the mainshaft is smaller than its drive gear on the countershaft to provide an overdrive effect. An overdrive five-speed transmission is shown in Figure 6-2. It also has a large countershaft gear driving a small mainshaft gear for an overdrive ratio in fifth speed.

PLANETARY OVERDRIVE

Another way of achieving an overdrive is to use a planetary gear system in a separate housing mounted on the rear of the transmission as shown in Figure 6-3. A simple planetary gear system is made from four components: (1) a **sun gear,** (2) a set of **planets,** (3) a carrier, and (4) a **ring gear.** The relation-

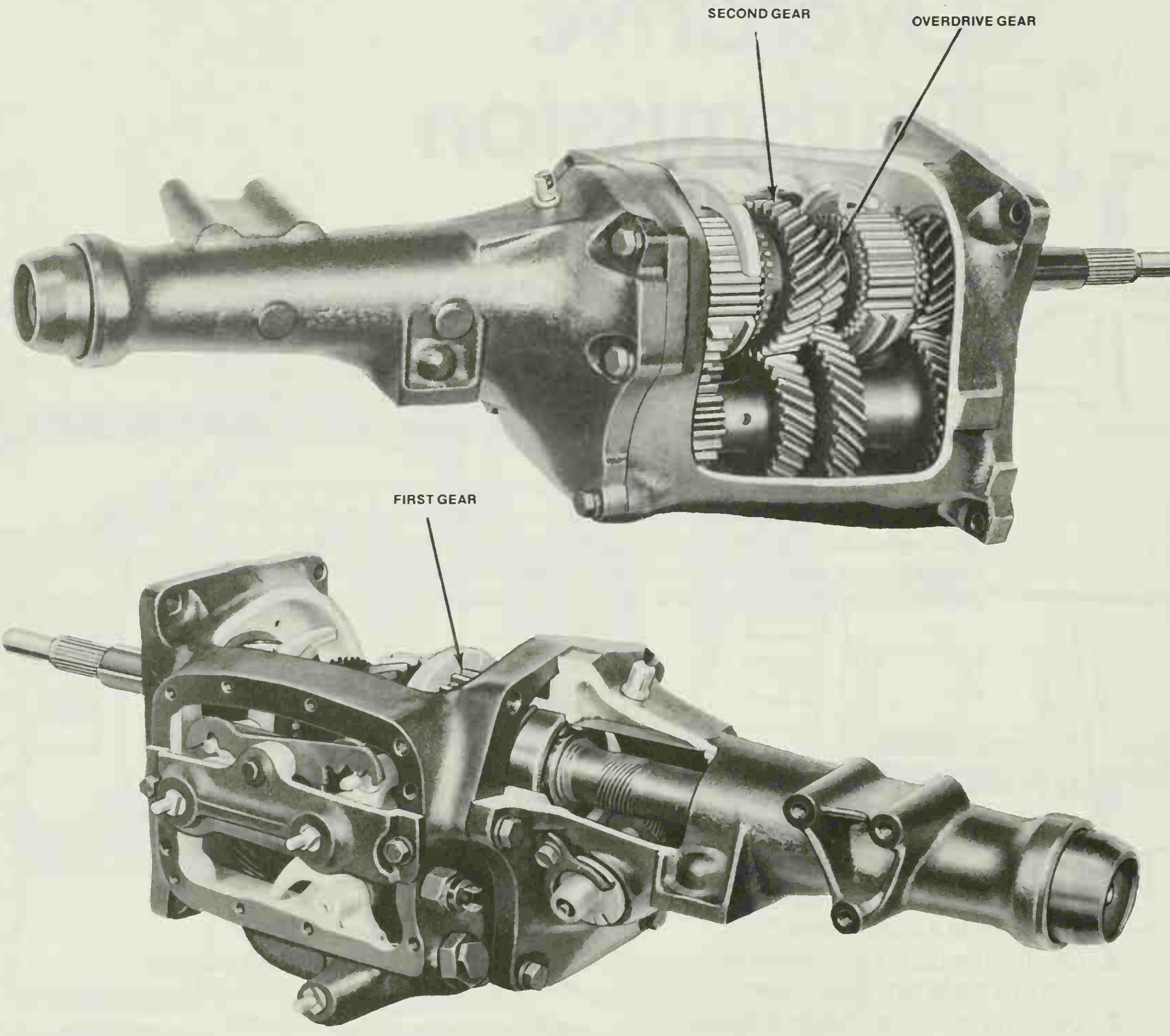


Figure 6-1. A four-speed overdrive transmission. (Chrysler Corporation)

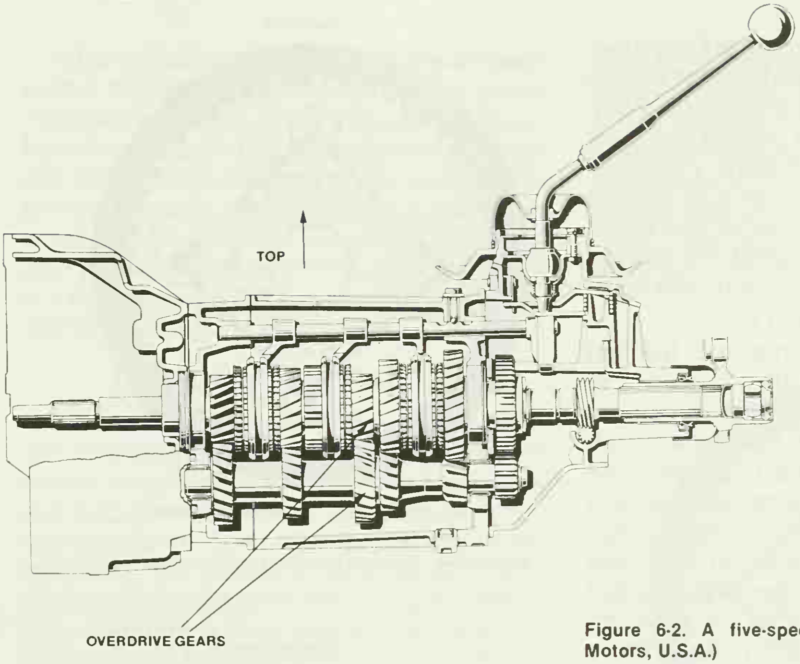


Figure 6-2. A five-speed overdrive transmission. (Fiat Motors, U.S.A.)

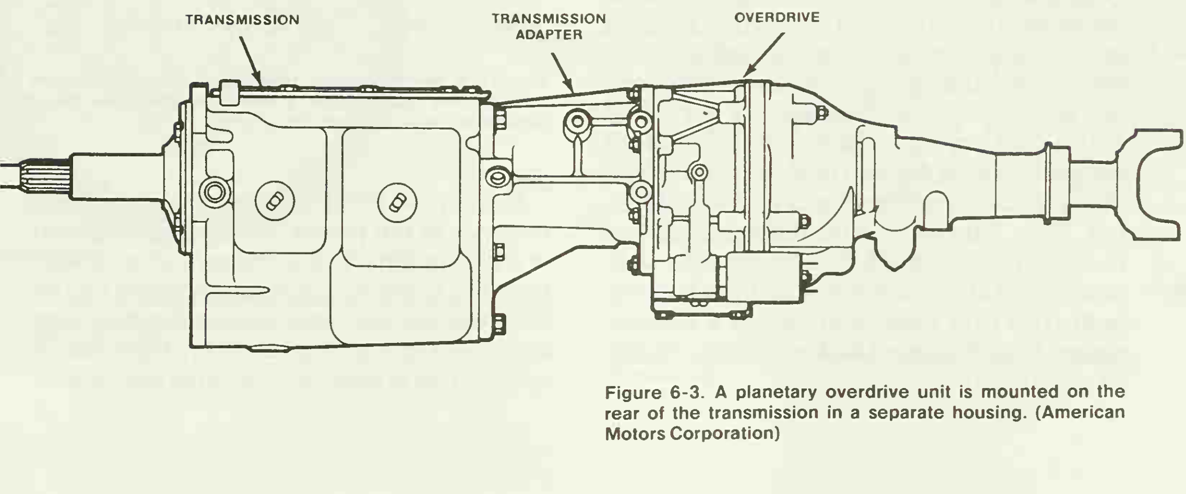


Figure 6-3. A planetary overdrive unit is mounted on the rear of the transmission in a separate housing. (American Motors Corporation)

ship of the components is shown in Figure 6-4.

The sun gear gets its name from the central position it occupies in a planetary gear set. In a simple planetary gear set the sun gear may have one of three functions: (1) it may be the gear to which input force is applied (the engine, for example, may be connected to it), in which case it is called the turning gear; (2) it may be the output or driven gear; or (3) it may be held stationary.

The planets get their name from the fact that they revolve around the sun gear. The carrier supports the planets. The planets (sometimes called **pinions**) are in mesh with both the sun gear and the ring gear. The planets are mounted in the carrier in such a way that they may "walk" around the sun gear while the carrier rotates, or they may "idle" on the stationary carrier while the sun and ring gears rotate. Like the sun gear, the carrier assembly may perform one of three functions: (1) it may be used as the input or turning member, (2) it may serve as the output or driven member, or (3) it may be held stationary.

The ring gear has internal teeth which mesh with the planets. Some manufacturers call this gear an **internal gear** or an **annular gear.** Like the sun gear and planet gears, the ring gear may perform one of three functions: (1) it may act as the input or turning gear, (2) it may serve as the output or driven gear, or (3) it may be held stationary.

Planetary gears may be used to provide a gear reduction and torque multiplication. They are used in this way in automatic transmissions. They may also be used to provide an overdrive. There are three possible conditions in which an overdrive may be achieved in a simple planetary gear set.

The first condition is to turn the planet carrier and hold the sun gear stationary. The ring gear becomes the output or driven member. What happens under these conditions is shown in Figure 6-5. The planets walk around the stationary sun and drive the ring gear. The ring gear is driven at a greater speed than the input to the carrier. This is an overdrive condition.

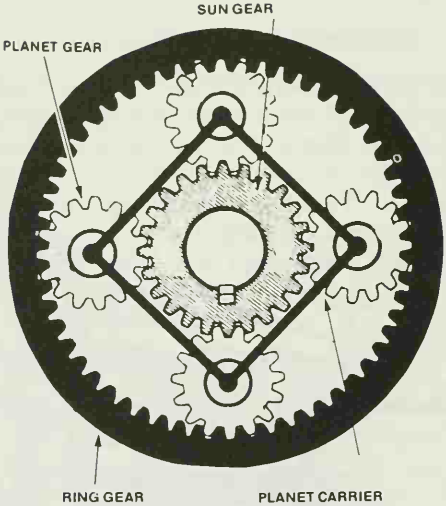


Figure 6-4. A simple planetary gear system.

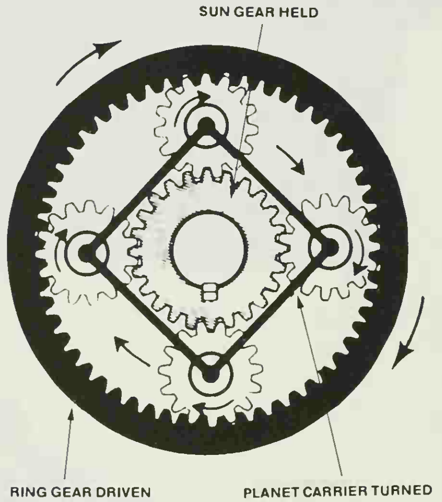


Figure 6-5. With the planet carrier as input and the sun gear held, the ring gear is driven in overdrive. (Chevrolet Motor Division of General Motors Corporation)

In the next condition the turning or input member is the planet carrier. The ring gear is held stationary, and the output or driven member is the sun gear as shown in Figure 6-6. The planets walk around the ring gear and drive the sun gear at an increase in speed. This is another overdrive condition.

In the last condition the stationary member is the planet carrier. The turned or input member is the ring gear. The output is taken from the sun gear. In a simple planetary gear set, holding the planet carrier causes the planets to act as idlers, creating a change in direction. As shown in Figure 6-7, the ring gear drives the sun gear through the planets in a reverse direction. This causes a reverse overdrive effect.

OVERDRIVE OPERATION

An overdrive system typically uses a planetary gearing system (Figure 6-8). The planet carrier is connected to the transmission output shaft through the sun gear and an overrunning clutch. The ring gear and overdrive mainshaft are a one-piece assembly. The system is activated by locking one of the planetary members with a clutch. The clutch is often applied hydraulically. Clutch operation is controlled electrically.

When the overdrive system is disengaged, power from the transmission output shaft is transmitted to the overdrive mainshaft through an **overrunning clutch.** The **sliding clutch** is held to the rear by clutch return spring pressure exerted through the thrust bearing and thrust bearing cover. This spring pressure loads a sliding clutch, holding the inner friction lining of the clutch in contact with the outside diameter of the ring gear on the mainshaft. Loading of the sliding clutch is further increased by reverse torque from the sun

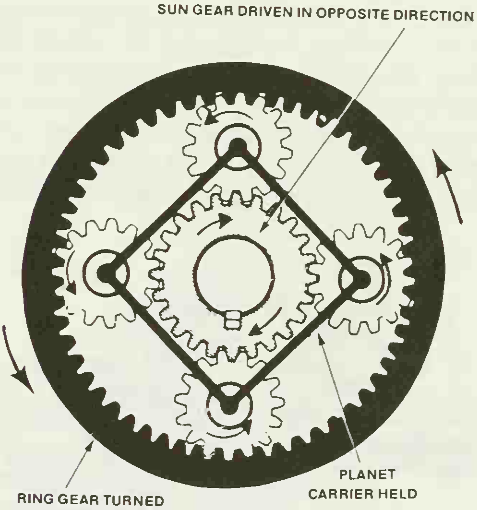


Figure 6-7. With the ring gear as input and the planet carrier held, the sun gear turns in the opposite direction at an overdrive. (Chevrolet Motor Division of General Motors Corporation)

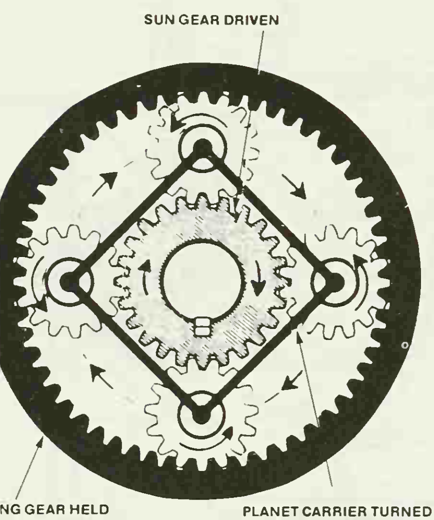


Figure 6-6. With the planet carrier as the input and the ring gear held, the sun is driven in overdrive. (Chevrolet Motor Division of General Motors Corporation)

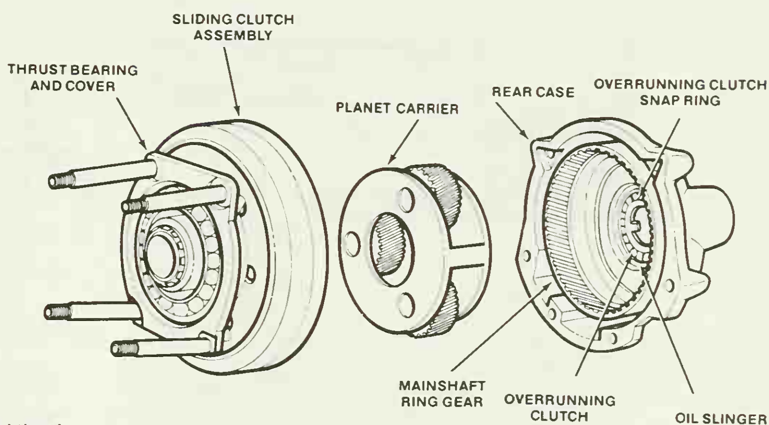


Figure 6-8. Overdrive planetary system. (American Motors Corporation)

gear which is splined to the sliding clutch. In this condition, the planetary gear train is locked, and overrun or reverse torque is absorbed by the sliding clutch. Because overrun or reverse torque is absorbed by the sliding clutch, the overrunning clutch does not freewheel when the overdrive is disengaged. The power flow through the disengaged overdrive system is shown in Figure 6-9.

The power flow through an engaged overdrive is shown in Figure 6-10. When the driver engages the overdrive control, the sliding clutch is moved forward by hydraulic pressure in the clutch apply cylinders until the outer friction surface of the clutch contacts the stationary clutch brake ring. Since the sliding clutch is splined to the sun gear, both components come to rest, and the sun gear becomes the reaction member for the planetary gear train. Because the planetary carrier is splined to the transmission output shaft and driven by it, the planetary gears revolve around the now stationary sun gear. As the planetary gears revolve around the sun gear, they turn the ring gear and mainshaft at a speed greater than that of the planetary carrier and transmission output shaft. The overrunning clutch can now **freewheel,** allowing the mainshaft to rotate faster than the transmission output shaft and provide an overdrive.

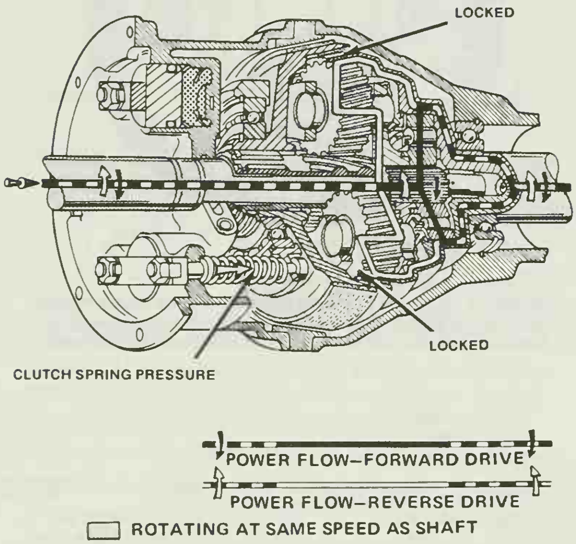


Figure 6-9. Power flow when the overdrive system is disengaged. (American Motors Corporation)

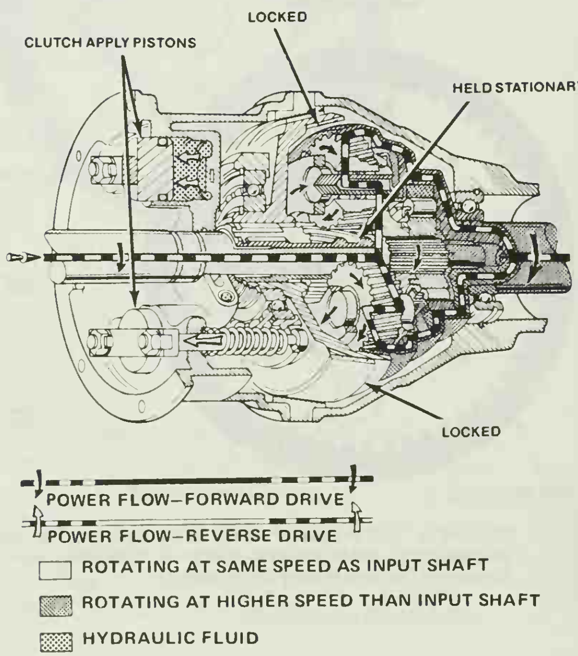


Figure 6-10. Power flow through the unit when the overdrive is engaged. (American Motors Corporation)

HYDRAULIC SYSTEM OPERATION

Hydraulic system pressure is developed by a cam-operated plunger-type pump. The pump cam is operated by the transmission output shaft through a drive key as shown in Figure 6-11. The pump draws oil from the air-cooled sump through the oil pan filter and delivers it through the nonreturn valve and pressure filter to the clutch apply pistons, solenoid valve, and relief valve assembly.

A spring-loaded piston in the relief valve assembly provides for smooth engagement and disengagement under all operating conditions. When the overdrive is disengaged, a residual system pressure of 20 to 40 pounds per square inch (psi) is maintained. With overdrive engaged, the system pressure increases to 520 to 540 psi and is controlled by the relief valve spring pressure.

When the overdrive is disengaged (Figure 6-12), oil is drawn from the sump, through the oil pan filter, and is delivered through the nonreturn valve assembly to the pressure filter and the clutch apply pistons.

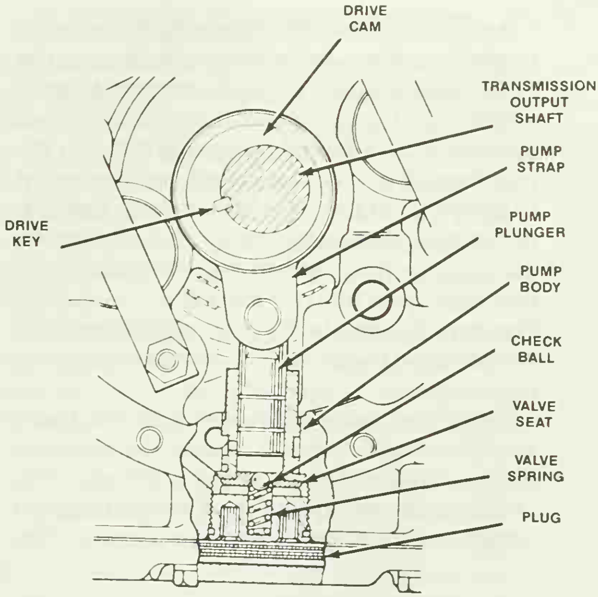


Figure 6-11. Overdrive hydraulic pump and valve assembly. (American Motors Corporation)

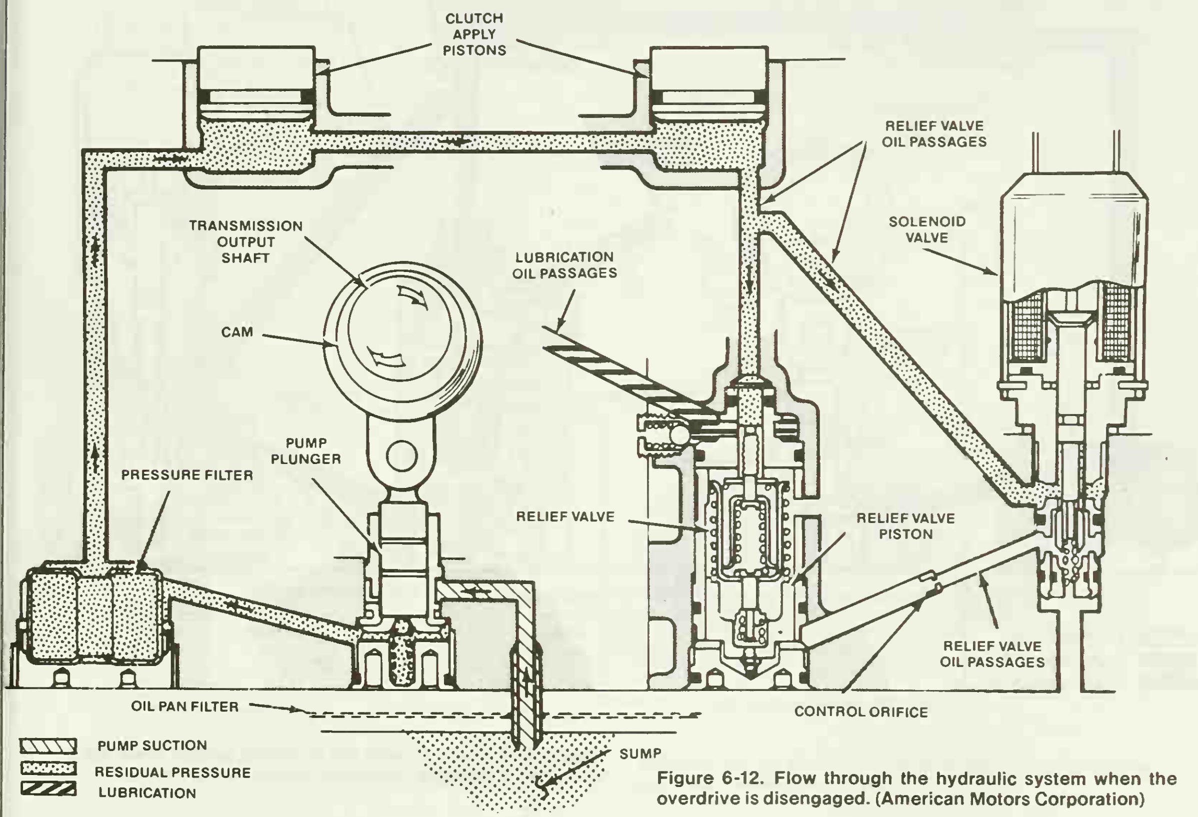


Figure 6-12. Flow through the hydraulic system when the overdrive is disengaged. (American Motors Corporation)

As the oil leaves the clutch apply pistons, it passes into the relief valve oil passages in the main case and acts upon the solenoid valve, which is closed. Because the solenoid valve is closed, the oil continues through the relief valve oil passages and into the relief valve exhaust port. Oil leaving the exhaust port is then delivered through the lubrication passage in the case to the mainshaft and planetary gear train for lubrication purposes. Pressure buildup in the lubrication passages is controlled by the spring-loaded lubrication relief valve.

Since the solenoid valve has not been energized and remains closed, oil pressure to the relief valve piston is withheld. The relief valve piston will then remain seated under the relief valve spring pressure. The relief valve residual pressure spring maintains residual oil pressure in the hydraulic system at 20 to 40 psi. This pressure is insufficient to move the clutch apply pistons but is necessary for lubrication and for smoother system response to engagement pressures flow through the hydraulic system during disengagement.

The flow through the system during engagement is shown in Figure 6-13. When the driver engages the overdrive, the solenoid is energized. The solenoid valve opens, and oil (at residual pressure) is delivered through the control orifice in the relief valve oil passage to the relief valve piston. Residual oil pressure then causes the relief valve piston to rise and begin compressing the relief valve springs.

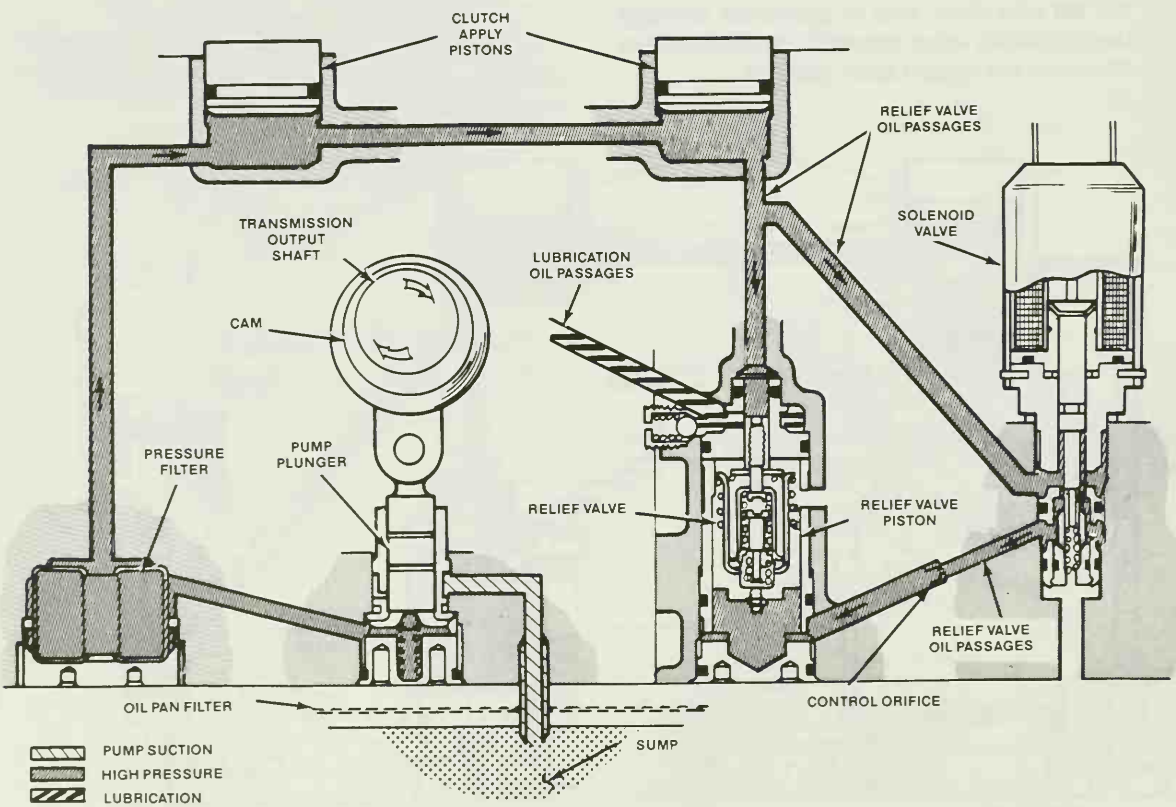


Figure 6-13. Flow through the hydraulic system when the overdrive is engaged. (American Motors Corporation)

As the relief valve springs are compressed, system pressure increases until the relief valve piston reaches the stop. At this point, the relief valve and residual pressure springs are fully compressed and the hydraulic system is now at its maximum operating pressure of 520 to 540 psi.

With maximum system pressure developed, the clutch apply pistons overcome clutch return spring pressure and move forward engaging the sliding clutch in the stationary brake ring.

Lubrication is provided by oil discharged from the relief valve exhaust port into the lubrication passage in the case. From this passage the oil is then pumped into the mainshaft and thrust bearing through lubrication holes drilled in the mainshaft. As lubrication oil leaves the mainshaft through the thrust bearing, it passes through the overrunning clutch and onto the overrunning clutch oil slinger. The oil slinger then directs oil to the oil catcher disc on the planet carrier and onto the planetary gear train through the hollow planetary gear pins. The mainshaft bearing is lubricated by oil fed through the mainshaft. Lubrication pressure is controlled by the lubrication relief valve.

ELECTRICAL CONTROL SYSTEM

The electrical control system allows the driver to engage or disengage the hydraulic system, which then engages or disengages the overdrive system. The electrical system consists of pushbutton overdrive control switch, a kickdown switch, a 3rd gear switch, a solenoid valve, and a **governor speed switch**. The electrical control circuit is shown in Figure 6-14.

An overdrive indicator lamp, in the instrument panel, is wired electrically (in parallel) to the solenoid valve. With overdrive engaged, the lamp will light and remain lit until overdrive is disengaged.

In order to engage the overdrive, all switches in the control circuit must be closed. If any switch remains open, the solenoid valve cannot be energized to engage the overdrive. All switches in the control circuit are actuated mechanically.

With the overdrive control switch On, the transmission in 3rd gear and the car speed at or above the governor cut-in speed, the circuit is completed and the battery current can energize the solenoid valve to effect overdrive engagement. If the transmission is shifted out of 3rd gear, if the control switch

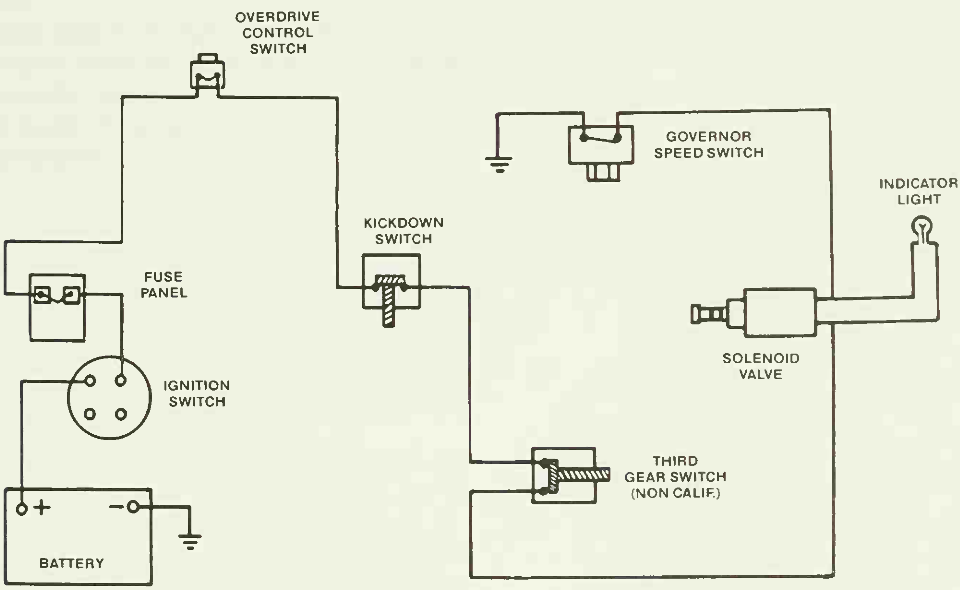


Figure 6-14. An electrical control system for an overdrive. (American Motors Corporation)

is turned off, or the kickdown switch is activated, or if the car speed drops below the governor cutout speed, the circuit will be broken and the solenoid de-energized, disengaging the overdrive.

When the car speed reaches the governor speed switch setting, centrifugal action of internal weights in the governor speed switch will close the contact points in the switch. These contacts will remain closed until car speed drops below the governor speed setting. The governor speed switch is attached to the speedometer governor switch adapter and is operated by the speedometer cable.

The 3rd gear switch is mounted in the transmission and is actuated by the 2nd-3rd shift rail. The 3rd gear switch remains open until the transmission is shifted into 3rd gear. This switch prevents overdrive operation in 1st, 2nd, or reverse gears.

The kickdown switch remains closed except when the accelerator pedal is fully depressed. This switch serves as a circuit interrupter, permitting temporary overdrive disengagement whenever additional acceleration is needed. The plunger-type kickdown switch is attached to a bracket mounted on the carburetor base and is actuated by the carburetor throttle lever.

The overdrive control switch is a pushbutton-type switch, which is mounted in the turn signal lever on the steering column. When the switch button is pressed, the overdrive will automatically engage after the transmission is in 3rd gear and car speed is fast enough. If the switch button is pressed again, the control circuit will open, preventing battery current from energizing the solenoid valve.

The solenoid valve is grounded through the governor speed switch. The valve remains closed until the solenoid is energized preventing sufficient hydraulic pressure to build up and engage the overdrive. The solenoid valve is installed in the overdrive unit.

NEW TERMS

Annular gear A gear which has internal teeth; same as a planetary ring gear.

Freewheel To overrun or turn without allowing power to be transmitted.

Governor speed switch Electric switch connected to the speed-sensing device.

Internal gear A gear wheel with teeth on its inside diameter.

Overdrive system A system of gears used to allow the transmission output shaft to turn faster than engine speed.

Overrunning clutch A clutch used in a planetary overdrive to disconnect the engine from the transmission output shaft.

Pinion A type of small round gear wheel which meshes with a larger gear to transmit torque.

Planetary gear system A gear system consisting of a sun gear, planet gears, planet carrier, and ring gear used to achieve an overdrive.

Planetary ring gear A gear in a planetary gear set with internal gear teeth.

Planets Small pinion gears used in a planetary gear set, in mesh with the sun and ring gears.

Sliding clutch A clutch applied by hydraulic pressure, used to engage and disengage a planetary overdrive.

Sun gear The center gear in a planetary gear system.

CHECK YOURSELF

1. Why does an overdrive transmission save fuel?
2. How may an overdrive be achieved with gears inside the transmission?
3. What are the main parts of a simple planetary gear system?
4. What is the result of turning the planet carrier and holding the sun gear stationary?
5. What is the result of turning the planet carrier and holding the ring gear stationary?
6. What is the result of turning the ring gear and and holding the planetary carrier stationary?
7. What is the purpose of the overdrive sliding clutch?
8. How is hydraulic pressure developed in an overdrive system?
9. How does hydraulic pressure engage an overdrive?
10. What is the purpose of the overdrive electrical control system?

CERTIFICATION PRACTICE

1. Mechanic A says gears inside the transmission may be used for an overdrive. Mechanic B says a planetary gear system on the rear of a transmission may be used for an overdrive.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. A simple planetary gear set can be operated by:
   a. Changing power input to a different member
   b. Obtaining the power output from a different member
   c. Holding one of the members
   d. All of the above
3. In a simple planetary gear set, if the ring gear is driven, the carrier turned, and sun gear held, the result is:
   a. Forward overdrive
   b. Forward reduction
   c. Reverse overdrive
   d. Reverse reduction
4. In a simple planetary gear set, if the ring gear is turned, carrier held, and sun gear driven, the result is:
   a. Forward overdrive
   b. Forward reduction
   c. Reverse overdrive
   d. Reverse reduction
5. A planetary overdrive system is engaged and disengaged by:
   a. Hydraulic system
   b. Electrical system
   c. Both a and b
   d. Neither a nor b

ANSWERS:

1. c, 2. d, 3. a, 4. c, 5. c

DISCUSSION TOPICS AND ACTIVITIES

1. Using a shop overdrive transmission, turn the input shaft and count the turns of the output shaft in each gear. What are the gear ratios?
2. Attach a tachometer to a vehicle with an overdrive. Drive the vehicle. Note the difference in engine speed at a constant vehicle speed with the overdrive engaged and disengaged.

Unit 7
Overdrive Transmission Service

Overdrive units that use an overdrive gear set inside the transmission are serviced in the same way as any manual transmission. Planetary overdrive systems, however, require some different service techniques. When these units malfunction, the overdrive may not engage, or disengage, may be slow to engage, may slip when engaged, or may be noisy. In this unit we will present the preventive maintenance, troubleshooting, and service procedures common to planetary overdrive systems.

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

Preventive Maintenance

7-1 Check overdrive lubricant level.

7-2 Drain lubricant, clean the filter, and refill the overdrive lubricant.

Troubleshooting

7-3 Perform an overdrive trouble diagnosis.

Service

7-4 Remove an overdrive assembly for service.

7-5 Disassemble an overdrive unit.

7-6 Clean and inspect overdrive parts.

7-7 Reassemble an overdrive unit.

7-8 Install an overdrive assembly.

JOB COMPETENCY 7-1
CHECK OVERDRIVE LUBRICANT LEVEL

The transmission and overdrive assemblies usually share a common lubricating oil supply. Lubricant level for both units is checked at the transmission fill plug.

The correct fill level for the transmission-overdrive assembly is to the edge of the transmission fill plug. Lubricant level should be checked at intervals specified by the manufacturer. Check lubricant level only after the transmission-overdrive assembly has been brought to operating temperature and the overdrive has been engaged and disengaged at least once.

Drive the vehicle long enough to get the transmission up to operating temperature. Engage and disengage the overdrive unit several times. Raise the vehicle on a hoist, making sure it is level. Remove the fill plug from the side of the transmission. Check to see that the lubricant level is at the edge of the fill hole. If necessary, add additional lubricant. Always use the type and viscosity of lubricant recommended by the manufacturer.

JOB COMPETENCY 7-2
DRAIN, CLEAN FILTER, AND REFILL OVERDRIVE LUBRICANT

Drain the overdrive unit and clean the filter at intervals specified by the manufacturer. To drain the transmission-overdrive assembly, remove the oil pan of the overdrive unit and the transmission drain bolt or drain plug. Raise the car on a hoist, making sure it is level. Place a support stand under the clutch housing and remove the rear crossmember. Remove the oil pan, oil pan gasket, and oil pan filter. Remove the pressure filter plug. The pressure filter and aluminum washer will come out with the plug. An exploded view of these components is shown in Figure 7-1.

Thoroughly clean the pressure filter and oil pan filter with solvent. Place these filters on a clean, lint-free shop cloth to drain until dry. If either filter is torn, split, or so severely plugged that it cannot be cleaned, replace the filter.

Install a new aluminum washer on the pressure filter plug. Position the pressure filter in the plug and install the assembled fil-

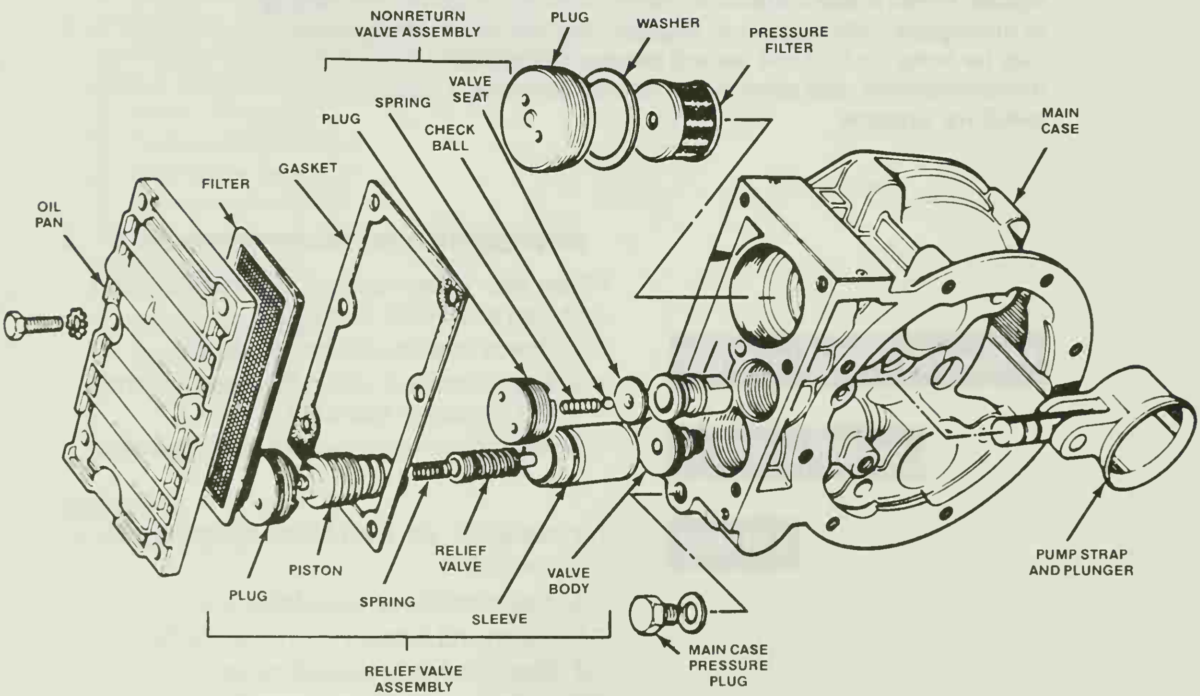


Figure 7-1. Exploded view showing oil pan, filter and pressure filter. (American Motors Corporation)

ter, washer, and plug. Tighten the plug to the recommended torque. Install the oil pan, oil pan gasket, and oil pan filter. Tighten the oil pan bolts to recommended torque. Add lubricant, as required, to the transmission and lower the car. Operate the overdrive, recheck the fluid level, and correct if necessary.

JOB COMPETENCY 7-3 PERFORM AN OVERDRIVE TROUBLE DIAGNOSIS

Overdrive problems typically show up as a unit that will not engage, not disengage, will slip or is noisy. First, locate the manufacturer's diagnosis guide. The diagnosis guide shows problems and their possible causes and corrections.

Overdrive is a mechanical gear and clutch assembly controlled by hydraulic and electrical circuits. A problem may be traced to any or all of these areas. Many of the control valves such as the solenoid, relief valve, non-return valve, and governor speed switch may be removed and replaced with the overdrive in the vehicle. If the diagnosis guide points to a problem in these areas, change the valve and retest the operation of the unit.

One test procedure common to overdrive units is a **hydraulic pressure test.** This is a test to determine whatever the hydraulic components are operating correctly. To perform a pressure test, first look up the pressure test specifications for the vehicle.

Lift and support the car so that the rear wheels are free to rotate. Check and correct the lubricant level at the transmission as described earlier. Place a support stand under the clutch housing and remove the rear cross-member. Remove the main case pressure plug and copper gasket and install a **pressure gage set** as shown in Figure 7-2.

Place the overdrive control switch in the Off position, start the engine, shift the transmission into 3rd gear, and run the engine at 25 to 30 miles per hour (mph). Hydraulic pressure should be to manufacturer's specifications at this speed. Place the overdrive control switch in the On position and increase car speed to 40 to 45 mph. When the overdrive engages, pressure should increase to the

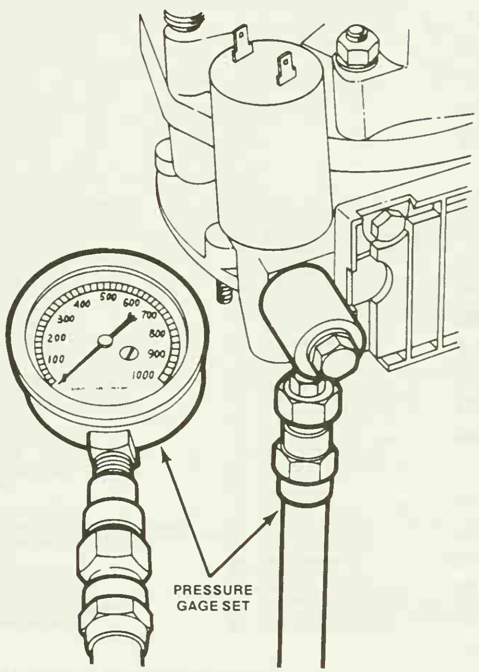


Figure 7-2. A pressure tester is used to diagnose overdrive problems. (American Motors Corporation)

manufacturer's specifications. Place the overdrive control switch in the Off position. When the overdrive disengages, hydraulic pressure should drop off.

If the pressure is higher or lower than specifications, the diagnosis guide will describe what components must be tested next. If the problem is not in one of the accessible valves or switches, the unit will have to be removed for service as described later.

Stop the engine, remove the pressure gage set, and install the main case pressure plug and copper gasket. Tighten the plug to the recommended torque. Install the rear crossmember. Tighten the nuts to the correct torque. Remove the supports and lower the car.

JOB COMPETENCY 7-4 REMOVE AN OVERDRIVE ASSEMBLY FOR SERVICE

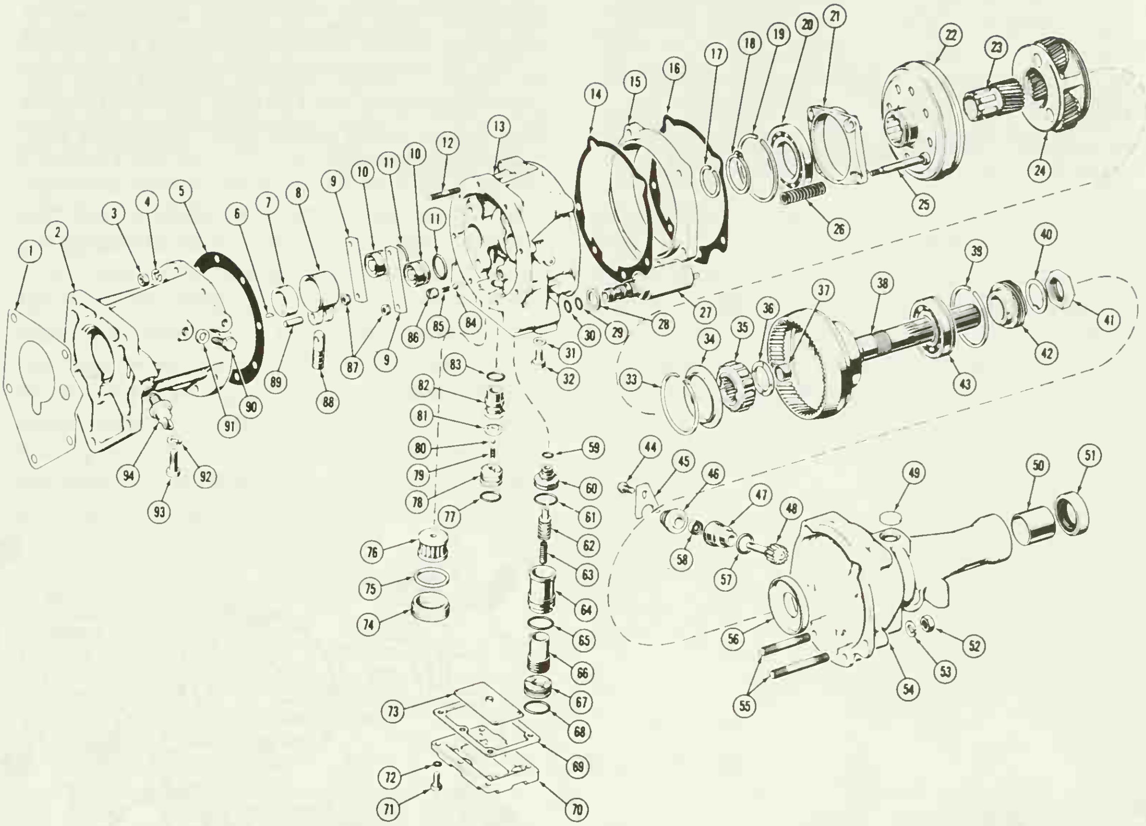
If diagnosis procedures indicate a problem inside the overdrive assembly, remove the assembly for service. Before removing the overdrive, operate the car, engage and disengage the overdrive *with clutch pedal depressed* (clutch disengaged). This procedure will relieve torque loading on overrunning clutch and pinion carrier and will ease removal of the assembly. Before beginning disassembly, *always disconnect the battery to prevent any accidental engine cranking and possible injury.*

Raise the car on a hoist. Disconnect the solenoid valve wires. Disconnect the speedometer cable at the governor speed switch. Remove the speedometer adapter clamp bolt and remove the clamp, governor speed switch, speedometer adapter, speedometer support, and speedometer driven gear from the speedometer bore. Remove the drive shaft. Mark the rear universal joint and pinion yoke for correct alignment at installation.

Disconnect shift rods at transmission shifter levers and slide rods forward out of the gearshift lever retainer bushings. Remove the mounting bolts that attach the retainer to the transmission adapter and remove the retainer. Place a support stand under the clutch housing. Remove the bolts attaching the rear support cushion to the transmission adapter and remove the crossmember with the rear support cushion attached. Remove the locknuts from the overdrive main case-to-transmission adapter studs and remove the overdrive.

JOB COMPETENCY 7-5 DISASSEMBLE AN OVERDRIVE UNIT

An exploded view of the overdrive unit like the one in Figure 7-3 makes a helpful guide in disassembly. Remove the solenoid valve with a wrench. Do not attempt to remove the solenoid by turning the body with pliers or similar tool as the solenoid could be damaged. Remove self-locking nuts that attach the clutch piston apply bars to the thrust bearing cover pins and discard the nuts. Remove the nuts, lock washer, and copper gaskets from the main case-to-rear-case studs and separate the main case assembly from the rear case assembly. Remove the loose clutch return springs from the main case and remove the clutch brake ring and gaskets from the main case. Do not pry on the clutch brake ring to remove it from the main case. If the brake ring is stuck, tap it lightly with a plastic mallet to loosen it.



1. GASKET TRANSMISSION TO ADAPTER
2 ADAPTER, TRANSMISSION
3 NUT, SELF LOCKING, MAIN CASE STUD
4 WASHER, LOCK
5 GASKET, MAIN CASE TO TRANSMISSION ADAPTER
6 KEY, PUMP STRAP CAM DRIVE
7 CAM PUMP STRAP
8. STRAP, PUMP
9 BAR, CLUTCH PISTON APPLY
10 PISTON, CLUTCH APPLY
11 SEAL, CLUTCH APPLY PISTON O-RING
12 STUD, MAIN CASE TO TRANSMISSION ADAPTER
13 MAIN CASE
14 GASKET, CLUTCH BRAKE RING (FRONT)
15. BRAKE RING, CLUTCH
16 GASKET, CLUTCH BRAKE RING (REAR)
17 RING, SUN GEAR SNAP
18 RING LOCK, SLIDING CLUTCH
19 RING, THRUST BEARING SNAP
20 BEARING, THRUST
21. COVER, THRUST BEARING
22 CLUTCH, SLIDING
23 SUN GEAR
24 ASSEMBLY, PINION CARRIER
25 BOLT, THRUST BEARING COVER (4 REOUIRED)
26 SPRING, CLUTCH RETURN (4 REOUIRED)
27 SOLENOID VALVE
28 WASHER, SOLENOID VALVE
29 SEAL, SOLENOID VALVE O-RING
30 SEAL, SOLENOID VALVE O-RING
31 GASKET, MAIN CASE PRESSURE PLUG
32 PLUG, MAIN CASE PRESSURE
33. RING, OVERRUNNING CLUTCH SNAP
34. SLINGER, OVERRUNNING CLUTCH DIL
35 ASSEMBLY, OVERRUNNING CLUTCH
36 WASHER, MAINSHAFT THRUST
37 BUSHING, MAINSHAFT SUPPORT (INCLUDED IN MAINSHAFT)
38 MAINSHAFT AND ANNULUS GEAR
39 RING, MAINSHAFT BEARING SNAP
40 WASHER, SPEEDOMETER DRIVE GEAR TAB
41 NUT, SPEEDDMETER DRIVE GEAR LOCK
42. GEAR, SPEEDOMETER DRIVE
43 BEARING, MAINSHAFT
44 BOLT, SPEEDOMETER ADAPTER CLAMP
45 CLAMP, SPEEDOMETER ADAPTER
46 ADAPTER, SPEEDOMETER TO GOVERNOR SPEED SWITCH
47 ADAPTER, SPEEDOMETER DRIVEN GEAR
48 GEAR, SPEEDOMETER DRIVEN
49 PLUG, EXPANSION
50 BUSHING, REAR CASE (INCLUDED IN CASE)
51 SEAL, REAR CASE OIL
52 NUT, SELF LOCKING, MAIN CASE TO REAR CASE STUD
53 WASHER, LOCK
54. REAR CASE
55. STUD, MAIN CASE TO REAR CASE
56 WASHER, DISC (NOT REMOVED INCLUDED IN REAR CASE)
57 SEAL, SPEEDOMETER ADAPTER O-RING
58 SEAL, SPEEDOMETER ADAPTER OIL
59 SEAL, RELIEF VALVE BODY O-RING (INNER)
60 BODY, RELIEF VALVE
61. SEAL, RELIEF VALVE BODY O-RING (OUTER)
62 ASSEMBLY, RELIEF VALVE AND SPRING
63 SPRING, RELIEF VALVE RESIDUAL PRESSURE
64 SLEEVE, RELIEF VALVE
65. SEAL, RELIEF VALVE SLEEVE O-RING
66 PISTON, RELIEF VALVE
67. PLUG, RELIEF VALVE PISTON
68 SEAL, RELIEF VALVE PISTON PLUG O-RING
69 GASKET, OIL PAN
70 DIL PAN
71 BOLT, OIL PAN
72 WASHER, LOCK
73. FILTER, OIL PAN
74 PLUG, PRESSURE FILTER
75. WASHER, PRESSURE FILTER (ALUMINUM)
76 FILTER, PRESSURE
77 SEAL, PUMP BODY O-RING
78 PLUG, PUMP BODY
79 SPRING, NONRETURN VALVE BALL SEAT
80 BALL, NONRETURN VALVE CHECK
81 SEAT, NONRETURN VALVE
82 BODY, PUMP PLUNGER
83. SEAL, PUMP PLUNGER BODY O-RING
84 BALL, LUBRICATION RELIEF VALVE CHECK
85. SPRING, LUBRICATION RELIEF VALVE
86 PLUG, LUBRICATION RELIEF VALVE
87. NUT, SELF LOCKING, CLUTCH PISTON APPLY BAR
88 PLUNGER, PUMP
89 PIN, PUMP PLUNGER
90. BDLT, GEARSHIFT LEVER RETAINER TO ADAPTER
91 WASHER, LOCK
92. WASHER, LOCK
93. BOLT, REAR SUPPORT CUSHION TO ADAPTER
94 SWITCH BACK-UP LIGHT

Figure 7-3. An exploded view of the overdrive unit is used as a disassembly guide. (American Motors Corporation)

Remove the oil pan, oil pan gasket, oil pan filter, and main case pressure plug from the main case and discard the oil pan gasket. Remove the pressure filter plug from the main case with the spanner tool as shown in Figure 7-4. Remove the pressure filter and aluminum washer. Remove the pump body plug and remove the nonreturn valve ball seat spring, check ball and valve seat. Remove the O-ring from the plug. Using pliers, carefully remove the clutch apply pistons from the bores in the main case as shown in Figure 7-5 and remove O-rings from the pistons. Discard the O-rings. Do not remove lubrication relief valve plug, spring, or ball from the main case.

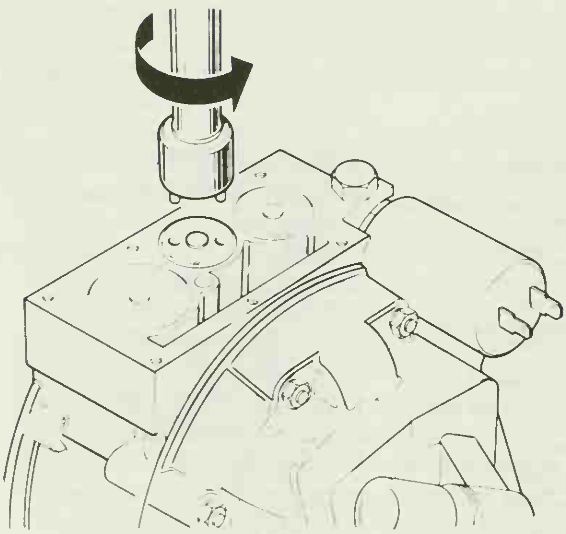


Figure 7-4. Removing the pressure filter plug from the case. (American Motors Corporation)

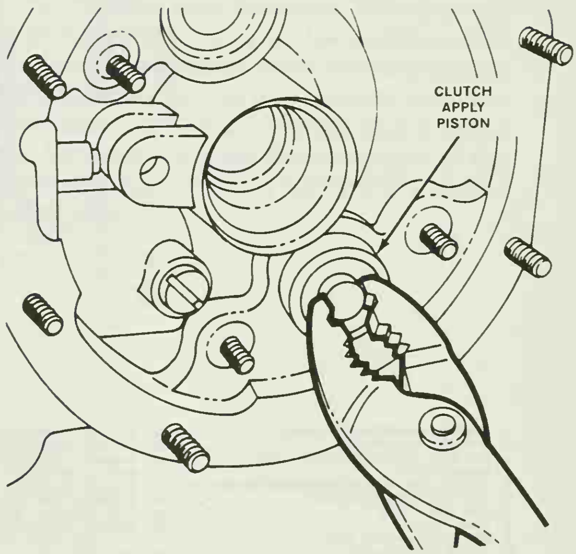


Figure 7-5. The clutch apply pistons are removed with pliers. (American Motors Corporation)

Remove the pump body and the assembled pump plunger and pump strap as follows. Push the pump body upward until it is unseated in the main case bore as shown in Figure 7-6. Carefully slide the pump plunger out of the pump body. Do not cock the piston in the body during removal. Remove the body from the main case bore. Remove the drive cam and key from the pump strap. Do not disassemble the pump strap and pump plunger. They are serviced as an assembly only. Remove the relief valve piston plug and remove the relief valve piston and relief valve residual pressure spring. Discard the O-ring on the plug. Using a magnet or needlenose pliers, carefully remove the relief valve and spring assembly. Do not attempt to remove the spring from the valve because doing so will impair the spring calibration.

Remove the relief valve sleeve and the relief valve body with a relief valve tool as shown in Figure 7-7. Insert the hooked end of the tool into the side orifice in the relief valve body. When the hooked end of the tool is in position in the side orifice of the relief valve body, slide the barrel of the tool downward to secure the hook end of the tool and exert a firm, steady pull on the tool handle. The tool will remove the valve body and sleeve together. Do not attempt to jerk the valve and sleeve out of the case bore because both parts could be damaged. Remove the O-rings from the valve body, sleeve, and plug. Discard the O-rings.

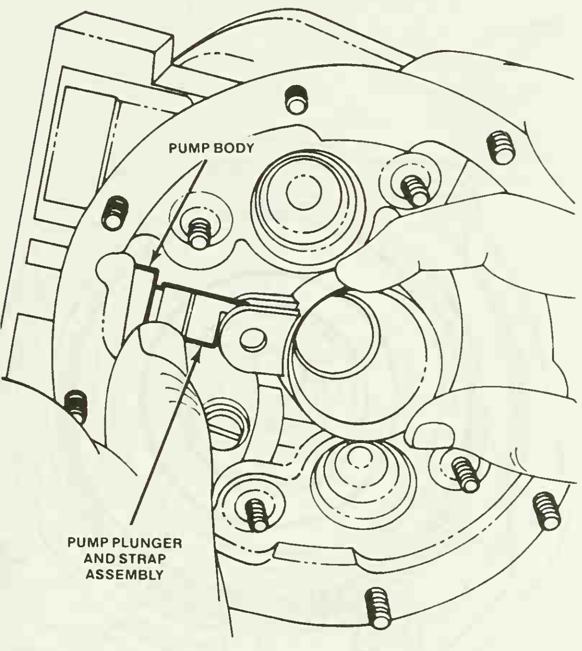


Figure 7-6. Removing the pump plunger and body. (American Motors Corporation)

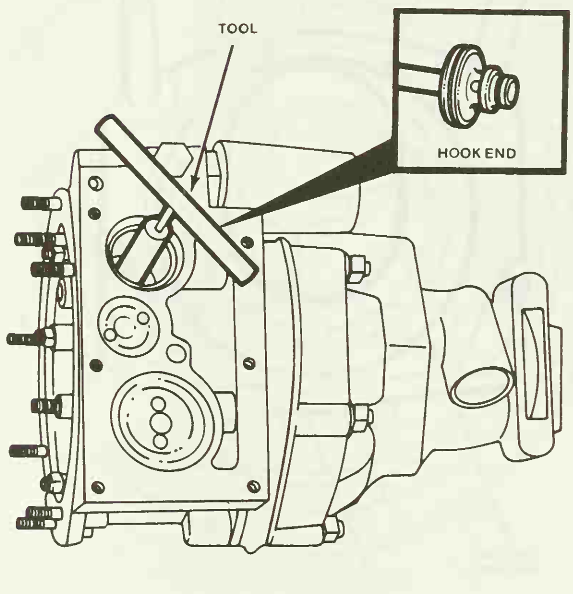


Figure 7-7. Removing the relief valve body and sleeve. (American Motors Corporation)

Remove the sliding clutch, sun gear, and thrust bearing cover assembly from the mainshaft ring gear in the rear case and remove the pinion carrier assembly from the mainshaft ring gear. Remove the sun gear snap ring and sliding clutch ring lock and push the sun gear out of the sliding clutch hub. Separate the thrust bearing and cover from the sliding clutch hub. Insert the removing tool into the sliding clutch hub as shown in Figure 7-8. Support the thrust bearing cover and tap on the end of the remover tool to drive the clutch hub from the thrust bearing. Remove the thrust bearing snap ring with a small screwdriver or pointed tool and press the bearing from the cover using an arbor press. Do not remove the thrust bearing cover bolts.

Remove the overrunning clutch snap ring and remove the brass oil slinger. Insert the overrunning clutch remover-installer tool into the bore in the mainshaft gear as shown in Figure 7-9. Hold the tool in position. Reach through the tool with your finger or with a relief valve body remover tool and pull the overrunning clutch into the tool. Remove the tool and overrunning clutch as an assembly. Remove the mainshaft thrust washer from the recess in the mainshaft ring gear. Remove the overrunning clutch from the tool and disassemble it. Do not, however, remove the tension spring from the cage.

Remove the expansion plug from the rear of the case by driving a punch or chisel into the plug and prying it out of the case. Remove the mainshaft ring gear as follows.

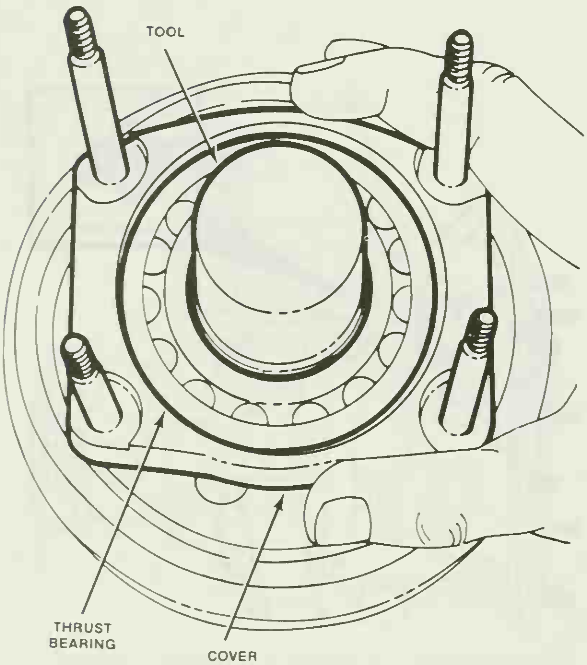


Figure 7-8. Driving the clutch hub from bearing and cover. (American Motors Corporation)

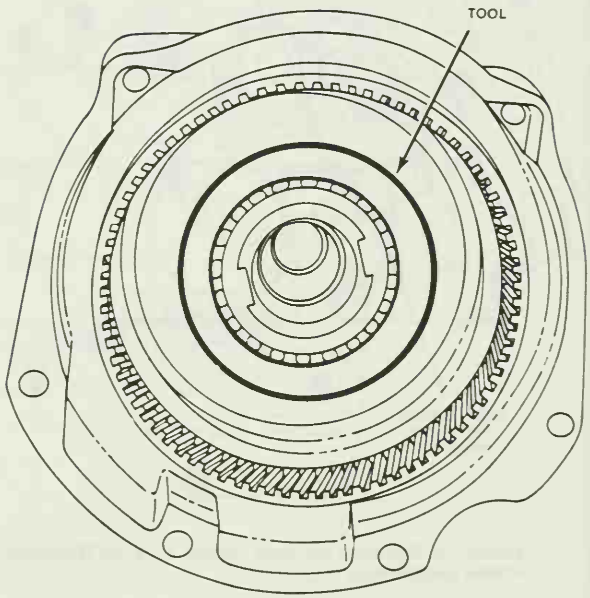


Figure 7-9. Removing the overrunning clutch. (American Motors Corporation)

Position the rear case on two wooden blocks as shown in Figure 7-10. Allow sufficient space between blocks for the mainshaft ring gear to pass through. With snap ring pliers, expand the mainshaft bearing snap ring, which is accessible through the expansion plug hole. Tap the end of the mainshaft with a plastic or lead hammer to drive the mainshaft out of rear case.

Place a torque adapter tool onto the spline end of the mainshaft to hold the mainshaft. Remove the speedometer drive gear locknut with the special tool shown in Figure 7-11. Remove the speedometer drive gear tab washer and speedometer drive gear. Remove the mainshaft bearing with an arbor press. Pry the rear case oil seal out of the case with a screwdriver and remove the mainshaft bearing snap ring from the machined groove in the rear case. Do not remove the disc or rear bushing from the rear case. These components are not serviceable items. They are available only as part of the rear case.

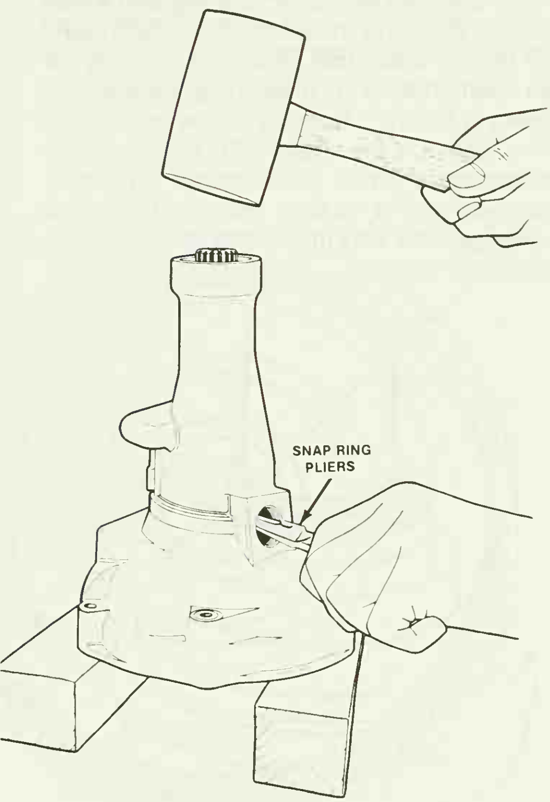


Figure 7-10. The mainshaft is removed by tapping with a rubber or plastic mallet. (American Motors Corporation)

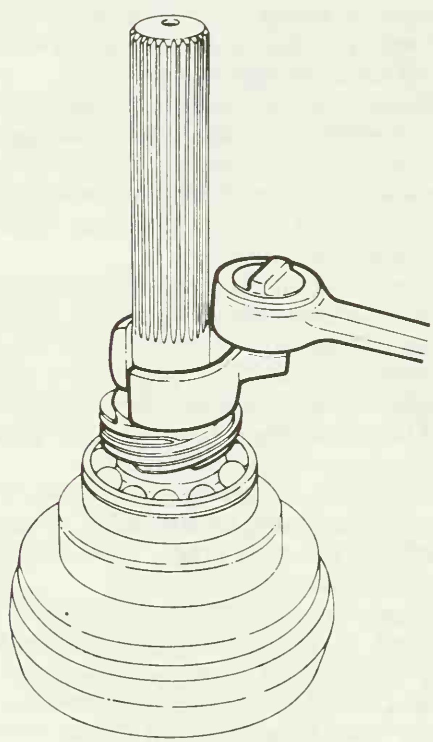


Figure 7-11. The speedometer gear locknut is removed with a special tool. (American Motors Corporation)

JOB COMPETENCY 7-6
CLEAN AND INSPECT OVERDRIVE PARTS

Thoroughly wash all the parts except the solenoid valve and sliding clutch in clean solvent. Do not use caustic cleaning agents on any part. After cleaning, place the parts on a clean shop towel to dry. Use a small hole brush or pipe cleaner to clean out all oil passages.

To clean the valve portion of the solenoid valve, place the valve portion in kerosene up to the threads. Allow it to soak until it is clean. Then air-dry the valve portion on a clean, lint-free shop cloth. Do not clean the sliding clutch in any type of solvent. Solvent cleaning may loosen the friction material or reduce its holding ability. To clean a sliding clutch, simply wipe it off with a clean, lint-free cloth.

When the parts are cleaned, inspect them carefully under a strong light. Look for cracks in the case or in the valve and piston bores. Check for nicks and scratches in the valve and piston bores. Look for worn or stripped threads on plugs and in valve bores and worn or stripped, threads on studs.

Inspect the rear case for cracks in the case or in the mainshaft bearing snap ring groove. Check for nicks, scratches, or warped mating surfaces and worn or stripped threads in stud holes. Inspect parts for a worn or loose rear bushing or disc washer.

Check the valves, pump, and pistons for signs of scratches, nicks, burrs, excessive wear, pitting, or corrosion. Check for wear, broken, or distorted relief valve springs. Inspect for torn, distorted, or plugged oil pan and pressure filters. Look for wear, grooves, burrs, or cracks in piston bores.

The clutch brake ring is inspected for any signs of grooving or distortion. Check for cracks at the stud holes. Look for burned clutch surfaces.

Inspect the sliding clutch assembly for worn, burned, loose, or peeling friction material and cracks in the clutch hub or friction surface. Look for worn or rough bearings and races in the thrust bearing. Check for weak, broken, or distorted clutch return springs.

When inspecting the mainshaft pinion carrier and sun gear, look for a loose or worn bushing in the ring gear bore and chipped, worn, or broken teeth in the ring gear. Look for worn, broken, chipped splines on the sun gear and mainshaft or a bent or distorted mainshaft. Inspect for cracked, worn, or chipped teeth on the pinion gears and rough, or worn mainshaft bearing.

The overrunning clutch is checked for a cracked or worn hub and rollers. Look for a broken or distorted spring, or a cracked, bent, or broken cage. Inspect for a cracked clutch hub or worn splines in clutch hub.

JOB COMPETENCY 7-7
REASSEMBLE AN OVERDRIVE UNIT

Before reassembling the overdrive, have on hand an overhaul gasket and seal set, new parts for those which show wear, and a container of clean lubricant to lubricate parts as they are assembled.

Lubricate the mainshaft bearing with transmission fluid and install the mainshaft bearing on the mainshaft. Seat the bearing on the mainshaft with a bearing installer as shown in Figure 7-12. Install the speedometer drive gear on the mainshaft. Install a new speedometer drive gear washer on top of the gear with a washer tab located in the mainshaft slot and install the speedometer drive gear locknut.

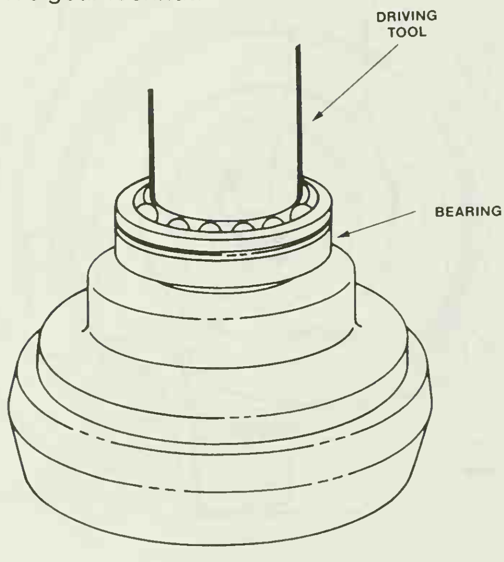


Figure 7-12. Installing the mainshaft bearing. (American Motors Corporation)

Install a new mainshaft bearing snap ring in the machined groove in the rear case. Position the snap ring so the butt ends are accessible through the expansion plug hole in the case. Place the mainshaft in an upright position and lower the rear case onto the mainshaft. Tap the end of the case with a plastic or lead hammer to start the mainshaft bearing into the counterbore in the case. When the bearing contacts the snap ring, expand the snap ring pliers and continue tapping the end of the case until the bearing is fully seated in the counterbore and the snap ring is seated in the bearing groove.

Lubricate the lip of the rear-case oil seal with transmission fluid. Install the seal with a seal driver. Install a new expansion plug in the rear case. Be sure to bottom the oil seal in the counterbore and to secure the expansion plug by striking the center of the plug with a flat-faced punch. Lubricate the mainshaft thrust washer with transmission fluid and install the washer into the recess in the mainshaft ring as shown in Figure 7-13.

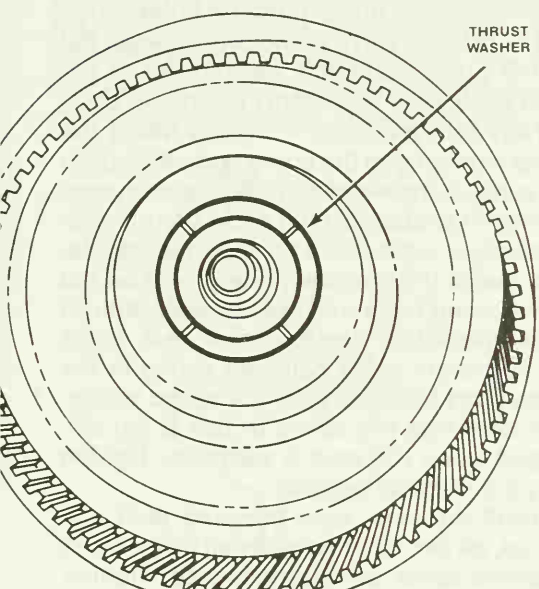


Figure 7-13. Location of mainshaft thrust washer. (American Motors Corporation)

To assemble the overrunning clutch, insert the hooked end of the hub spring, as shown in Figure 7-14, into the spring locating hole in the cage. Hold the cage and rotate the hub (against spring pressure) until cage tabs are aligned with hub slots, then seat the cage on the hub. Place the assembled cage and hub into the overrunning clutch installer tool with the open end of the cage facing out as shown in Figure 7-15. Feed the clutch rollers into the cage slots through the gate in the tool. Turn the cage clockwise when installing a roller. Lubricate the overrunning clutch assembly with transmission fluid and install it in the bore of the mainshaft ring gear. Install the brass oil slinger, and install the overrunning clutch snap ring. Be sure the snap ring is fully seated in its groove.

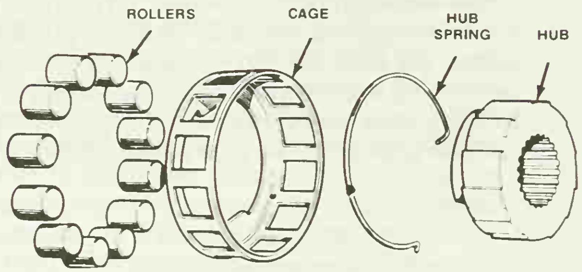


Figure 7-14. Overrunning clutch parts. (American Motors Corporation)

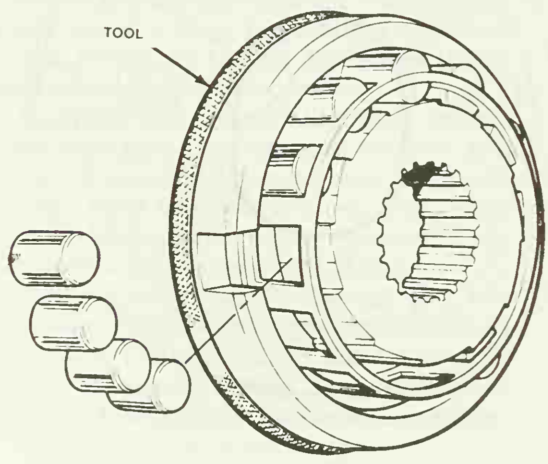


Figure 7-15. Installing rollers in overrunning clutch. (American Motors Corporation)

Lubricate the pinion carrier assembly with transmission fluid and install it in the mainshaft ring gear. Press the thrust bearing into the thrust bearing cover with an arbor press and install the thrust bearing snap ring. Lubricate the bearing with transmission fluid. To install the thrust bearing and cover assembly onto the sliding clutch hub, position the thrust bearing and cover assembly clutch hub. Tap the cover with a plastic or lead hammer to start the bearing onto the hub. Turn the assembly over, hand support the thrust bearing cover, insert the installer-remover, as shown in Figure 7-16 into the clutch hub and drive the hub into the thrust bearing.

Install the sun gear into the sliding clutch hub. Install the sliding clutch ring lock and sun gear snap ring. Be sure the ring lock and snap are fully seated. Install the sliding clutch assembly onto the mainshaft ring gear while engaging the sun gear in pinion gears. Be sure the sliding clutch is seated on the ring and the sun gear is fully engaged in the pinion gears. Rotating the mainshaft while engaging the sun gear helps installation.

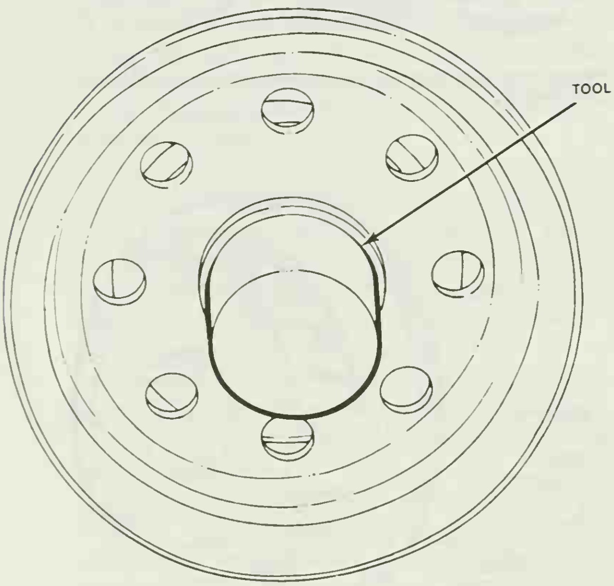


Figure 7-16. Installing the clutch hub in thrust bearing and cover. (American Motors Corporation)

Lubricate the clutch apply pistons with transmission fluid, install new O-ring seals, and install the pistons in the main case bores. Lubricate all relief valve assembly components with transmission fluid and install new O-ring seals on the relief valve body, relief valve sleeve, and relief valve piston plug. Insert the relief valve body into the main case bore. Align the oil hole in the relief valve sleeve with the oil hole in the bore and insert the sleeve. Push the sleeve firmly into the bore to seat the sleeve and valve body. Install the relief valve and spring assembly in the relief valve body, and install the relief valve residual pressure spring in the relief valve and spring assembly. Install the relief valve piston in the relief valve sleeve and install a relief valve piston plug. Tighten the plug to specifications with a torque wrench.

Install the pressure filter into the main case bore. Place a new aluminum washer on the pressure filter plug and install the plug. Tighten the plug to specified torque. Lubricate the pump plunger assembly, pump body, and nonreturn valve seat with transmission fluid. Install new O-ring seals on the pump body and pump plug.

To install the pump plunger, pump body, and nonreturn valve components, align flat on the pump body with the oil hole in the main case bore and insert the pump body halfway into the bore. Carefully insert the pump plunger into the pump body, then push the pump body completely into the main case bore until seated. Do not allow the plunger to misalign in the pump body during installation. Install the nonreturn valve seat on top of the pump body and place the nonreturn valve check ball into the valve seat. Place the nonreturn valve ball seat spring in the pump body plug and install plug and spring. Take care that the spring or ball is not dislodged when the plug is installed. Tighten the plug to specifications.

Install the main case pressure plug and gasket, oil pan filter, new oil pan gasket, and oil pump cover on the main case. Tighten pan bolts and pressure plug to specifications.

Mount the rear case assembly upright in a vise with soft jaws. Do not overtighten the

vise on the aluminum rear case. Install new clutch return springs on the thrust bearing cover bolts. Install the first clutch brake ring gasket on the rear case. Install the clutch brake ring into the rear case with the tapered surface of the brake ring facing the rear of the case and install the second new clutch brake ring gasket on the brake ring. Be sure the gaskets and brake ring are aligned with stud holes in the rear case.

Apply a light coat of sealer to the main case-to-rear-case studs. Position the main case assembly, align the studs, and lower the main case assembly onto the rear case assembly. As the main case assembly is being lowered, align the thrust bearing cover bolts with bolt holes in the main case as shown in Figure 7-17. Install nuts on the main-case-to-rear-case studs. Tighten the nuts progressively to avoid misaligning the main case or rear case as both components are under clutch return spring pressure. Tighten the nuts to specified torque.

Install the clutch apply bars on the thrust bearing cover bolts and secure with new locknuts. Tighten the nuts to specified torque. Install the solenoid valve. Tighten the solenoid valve securely but do not overtighten. Lubricate the new drive cam with transmission fluid and install the cam and a new drive key in the pump strap. Pour approximately one pint of transmission fluid into the oil pan through the access hole in front of the main case.

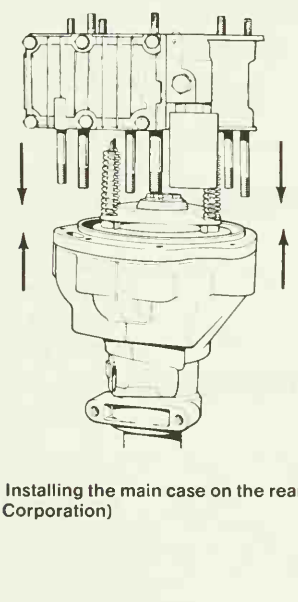


Figure 7-17. Installing the main case on the rear case. (American Motors Corporation)

JOB COMPETENCY 7-8 INSTALL AN OVERDRIVE ASSEMBLY

Clean the gasket surfaces of the overdrive main case and transmission adapter. Apply a light coat of sealer to both surfaces and position a new gasket on the overdrive main case, taking care not to tear the gasket when installing it over main case studs. Install a spring clip on the transmission output shaft, if removed. Use a long screwdriver to align overrunning clutch splines with transmission output shaft splines. Align the drive slot in the transmission output shaft with the drive key in the plunger pump drive cam and install the overdrive. Be sure the transmission output shaft splines are aligned with splines in the overrunning clutch hub. DO NOT force engagement when installing.

Install the locknuts and lock washer on the overdrive main-case-to-transmission adapter studs. Tighten the nuts to specified torque. Install the rear crossmember with rear support cushion attached. Tighten the rear crossmember stud nuts to specified torque. Tighten the support cushion-to-transmission adapter bolts to specified torque and remove the support stand from under the clutch housing. Connect the ground strap to the floor pan.

Install the gearshift lever retainer on the transmission adapter. Position the shift rods in retainer bushings and connect the shift rods to the transmission shifter levers.

Install the drive shaft. Be sure to align index marks made during removal. Tighten the universal joint strap bolts to the specified torque. If there are U-bolts, tighten the U-bolt nuts to the specified torque.

Assemble the speedometer gear, speedometer support, speedometer adapter, and governor speed switch and install the speedometer bore in the overdrive. Install the speedometer adapter clamp and clamp bolt. Tighten the bolt to specified torque.

Connect the speedometer cable to the governor speed switch. Connect the solenoid valve wire. Check and correct the fluid level in the transmission. Lower the car. Test-drive the vehicle and check for proper operation.

NEW TERMS

Hydraulic pressure test An overdrive test in which a pressure gage is connected to the hydraulic system to determine pressures.

Pressure gage set Gages installed in overdrive pressure ports to measure operating pressure.

JOB COMPETENCY TEST

1. Describe how to check the lubricant level in an overdrive unit.
2. Explain how to drain and refill the lubricant in an overdrive unit.
3. Why is it necessary to clean the overdrive filter when changing lubricant?
4. How do overdrive problems usually show up?
5. Describe the steps to follow in troubleshooting an overdrive system.
6. Explain how to inspect overdrive parts for damage and wear.
7. Describe how to remove an overdrive assembly from a vehicle.
8. Explain how to disassemble an overdrive unit.
9. Describe how to assemble an overdrive unit.
10. Describe the steps to follow in installing an overdrive in a vehicle.

CERTIFICATION PRACTICE

1. When an overdrive unit is drained and refilled with lubricant, the mechanic:
   a. Removes the oil pan
   b. Cleans the filter
   c. Both a and b
   d. Neither a nor b
2. When changing a lubricant the mechanic cleans or replaces:
   a. Oil pan filter
   b. Pressure filter
   c. Both a and b
   d. Neither a nor b
3. A diagnosis test common to overdrives is:
   a. Hydraulic pressure test
   b. Vacuum modulater test
   c. Both a and b
   d. Neither a nor b
4. Overdrive problems may show up as a unit that:
   a. Is slow to engage
   b. Will not engage
   c. Slips when engaged
   d. All the above
5. Mechanic A says overdrive parts are cleaned in solvent.
   Mechanic B says overdrive parts are cleaned by steam cleaning.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
6. Before removing an overdrive:
   a. Disconnect fuel lines
   b. Disconnect vacuum lines
   c. Disconnect the battery
   d. None of the above
7. Which of the following overdrive parts is not cleaned in solvent:
   a. Sliding clutch
   b. Solenoid valve
   c. Both a and b
   d. Neither a nor b
8. Overdrive parts are inspected for:
   a. Distortion
   b. Cracks
   c. Overheating
   d. All the above
9. Before reassembly the mechanic needs:
   a. New parts
   b. Gasket set
   c. Lubricant
   d. All the above
10. After reassembling and installing the overdrive unit, the mechanic should:
    a. Perform pressure test
    b. Test-drive
    c. Both a and b
    d. Neither a nor b

ANSWERS:

1.c, 2.c, 3.a, 4.d, 5.a, 6.c, 7.c, 8.d, 9.d, 10.b

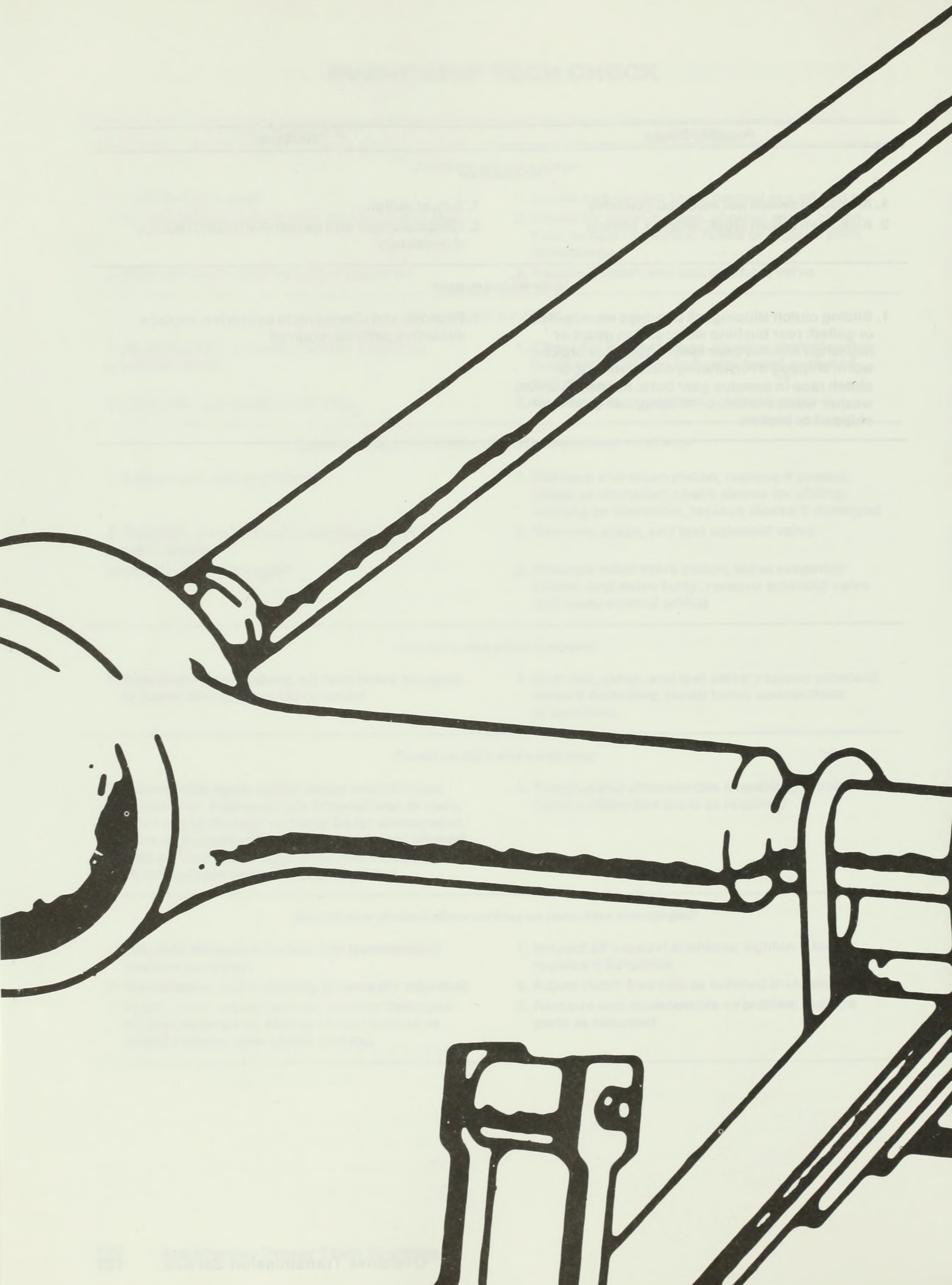
DISCUSSION TOPICS AND ACTIVITIES

1. Perform a diagnosis procedure on an overdrive with a malfunction.
2. Disassemble and reassemble a shop overdrive unit. Inspect all the parts for wear.

OVERDRIVE TECH CHECK

Possible Cause	Service
Overdrive will not engage	
1. Low lubricant level	1. Check and correct level; correct any oil leaks
2. Open switch or wire in electrical control circuit	2. Check for loose, broken, shorted wires, blown fuse, or open switches; repair or replace parts as required
3. Solenoid valve sticking, grounded, open	3. Remove, clean, and test solenoid valve
Overdrive will not disengage	
1. Closed switch or shorted wire in electrical control circuit	1. Check for shorted wires, sticking control switch pushbutton (at turn indicator lever) or closed switches
2. Solenoid valve stuck, or shorted	2. Remove, clean, and test solenoid valve
Slow disengagement and/or overdrive freewheels on overrun	
1. Relief valve piston sticking	1. Remove and clean piston; replace if scored, pitted or corroded; check sleeve for pitting, scoring, or corrosion, replace sleeve if damaged
2. Solenoid valve oil feed holes plugged or valve sticking	2. Remove, clean, and test solenoid valve
3. Control orifice plugged	3. Remove relief valve piston, valve assembly sleeve, and valve body; remove solenoid valve and clean control orifice
Overdrive slips when engaging	
1. Solenoid valve sticking, oil feed holes plugged, or loose wire at solenoid terminal	1. Remove, clean, and test valve; replace solenoid valve if defective; repair loose connections at terminals
Overdrive slips when engaging	
1. Worn clutch apply piston seals; worn friction material on sliding clutch; internal leak in case; worn pump plunger or pump body; damaged or worn gear components; pump body not aligned with oil feed slot in case bore; annulus gear clutch surface worn, burned, or galled	1. Remove and disassemble overdrive; repair or replace defective parts as required
Shudders or chatters when backing up (overdrive disengaged)	
1. Loose or defective engine and transmission support cushions	1. Inspect all support cushions; tighten if loose; replace if defective
2. Transmission clutch slipping (incorrectly adjusted)	2. Adjust clutch free play as outlined in clutch section
3. Weak clutch return springs; worn or damaged friction material on sliding clutch; burned or galled annulus gear clutch surface	3. Remove and disassemble overdrive; replace parts as required

Possible Cause	Service
No kickdown	
1. Kickdown switch not adjusted correctly	1. Adjust switch
2. Kickdown switch stuck, shorted, broken	2. Check plunger and switch continuity; replace if necessary
Noisy when engaged	
1. Sliding clutch slipping; all bearings worn, pitted, or galled; rear bushing worn; pinion gears or mainshaft annulus gear teeth chipped or broken; worn, chipped overrunning clutch rollers, or clutch race in annulus gear bore; mainshaft thrust washer worn, broken, or missing; sun gear teeth chipped or broken	1. Remove and disassemble overdrive; replace defective parts as required



Unit 8
Drive Shaft Assembly

When a vehicle uses a differential that is separate from the transmission, the torque developed by the engine must be transferred to the differential. This is the function of the **drive shaft** assembly. The drive shaft assembly is sometimes called the **drive line assembly** or **propeller shaft.** The drive shaft assembly is connected at one end to the output shaft of the transmission and at the other end to the **drive pinion** in the differential.

The drive shaft's job is made difficult by the fact that, while the transmission is mounted stationary to the automobile frame, the rear axle assembly is mounted on springs. This means that the rear axle assembly can move up and down as the vehicle moves over bumps and holes. The drive line has to be designed so that it can move to changes in both angle and length. A drive shaft may be connected to the differential in a straight line when the automobile is on level ground, but as the rear axle moves up or down, the drive shaft has to operate at an angle. The drive shaft also must be able to adjust in length, because the distance between the transmission and differential assembly changes as the rear axle assembly moves up and down.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe the parts and operation of the common types of drive assemblies.
2. Identify the parts of a drive shaft.
3. Explain the operation of a simple universal and slip joint.
4. Describe how the universal-joint operating angle is determined.
5. Explain how velocity changes occur in a universal joint.
6. Describe the parts and operation of a constant-velocity universal joint.

TYPES OF DRIVE SHAFT ASSEMBLIES

There are several types of drive line assemblies in use. Each is designed to handle a change in drive line length and angle. One type of drive called the **torque tube drive** is shown in Figure 8-1. A solid drive shaft is enclosed in a large hollow tube called a torque tube. A flexible joint, called a **universal joint,** is mounted at the transmission end of the drive shaft. The universal joint (also called a U-joint) allows the entire drive assembly to move up and down to change length.

A change in the length of the drive assembly is achieved by a **slip joint.** The output shaft of the transmission has a set of long slots, or splines, around its diameter. The universal joint yoke that attaches to the transmission output shaft also has a set of splines, which slip over those on the transmission output shaft. These long splines allow the drive assembly to move back and forth on the transmission output shaft. This in turn allows the drive shaft to change length as the rear axle assembly moves up and down.

In the torque tube drive line, the drive shaft is always in perfect alignment with the rear axle drive pinion. This is because the torque tube, which supports the drive shaft, is rigidly attached to the differential housing. The disadvantages of this system are that it is extremely heavy, and the drive line and rear axle assembly may have to be removed to service the transmission.

The disadvantages of the torque tube drive led to the design of the **Hotchkiss drive.** The Hotchkiss drive is now used in most front-engine, rear-drive automobiles.

The Hotchkiss drive assembly is shown in Figure 8-2. An open drive shaft is used. Universal joints attached to each end of the drive shaft allow it to operate at different angles. Each universal joint consists of two **yokes** connected in the center by a cross. Bearings, installed where the yokes are attached to the cross, allow the yokes to swivel in relation to the cross. Yokes are attached to each end of the drive shaft, the transmission output shaft, and the rear axle assembly. As the rear

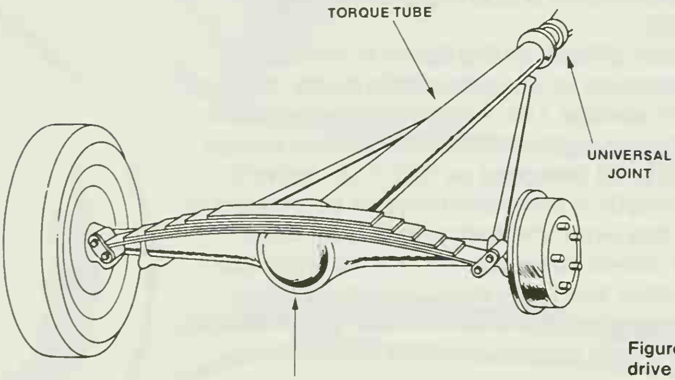


Figure 8-1. The drive shaft is enclosed in a torque-tube-style drive assembly. (Ford Motor Company)

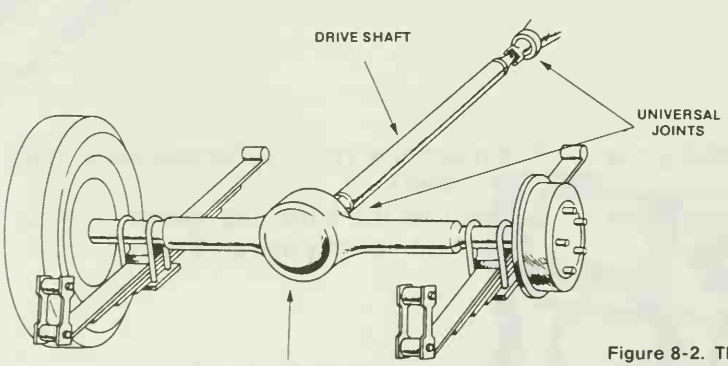


Figure 8-2. The drive shaft is exposed in a Hotchkiss drive assembly. (Ford Motor Company)

axle assembly moves up and down, the drive shaft yokes can swivel on the crosses and allow a change in driving angle. A change in drive line length is achieved with a slip joint at the transmission end just as in the torque tube drive.

In the Hotchkiss drive line, the differential housing is usually held in such a position that the drive shaft and drive pinion are not in perfect alignment. In fact, their center lines are usually at an angle, as we shall see later.

In the typical Hotchkiss drive line assembly the differential is mounted by springs to the frame. The drive line assembly must handle the up and down movement of the differential.

The **independent rear suspension system** shown in Figure 8-3 has a differential carrier that is solidly mounted to the frame. Axle shafts with universal joints similar to those used with transaxles are required to take care of wheel up and down movement. The drive shaft typically uses two or more universal joints to handle the angle between the transmission and differential carrier.

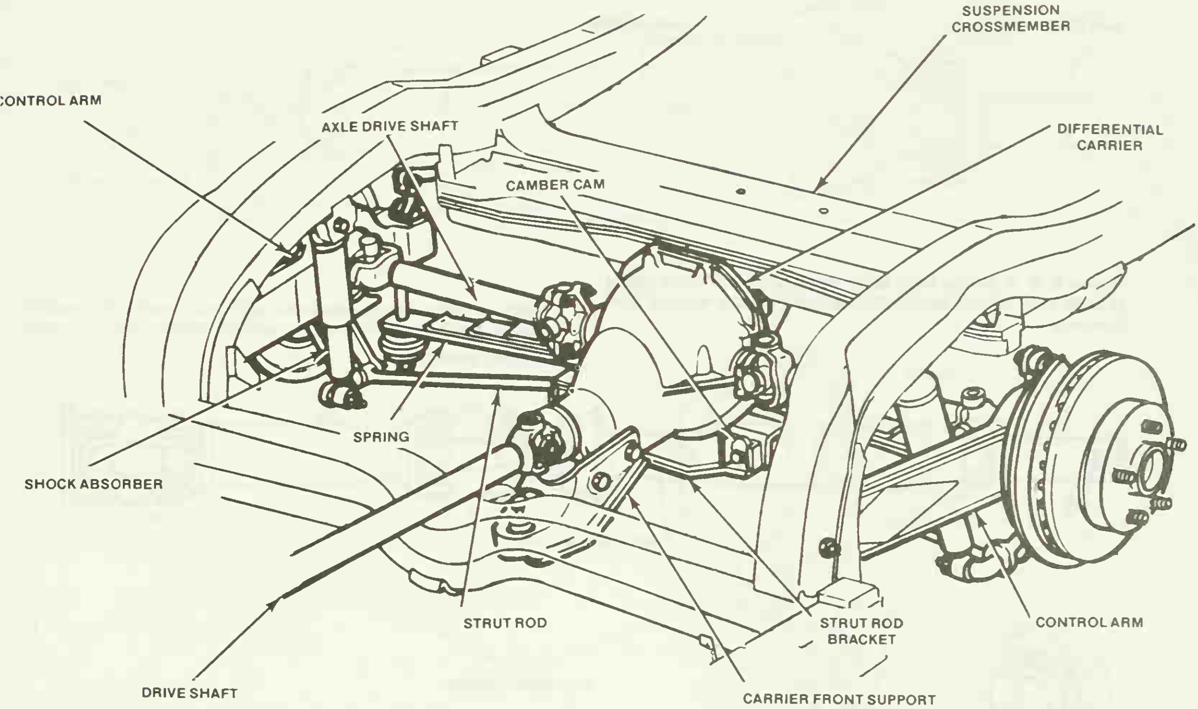


Figure 8-3. The differential carrier is solidly mounted to the frame in an independent rear suspension. (Chevrolet Motor Division of General Motors Corporation)

DRIVE SHAFTS

The drive shaft, sometimes called the **propeller shaft,** is a steel tube used to transmit power from the transmission output shaft to the rear axle assembly. To take care of different model, wheel base, and transmission combinations, drive shafts come in different lengths and diameters. Many drive shafts are made from a single tube as shown in Figure 8-4. A yoke assembly is welded to each end of the tube. The yoke is used to mount the universal joint to the drive shaft.

When the drive assembly must be extremely long, as in the case of a full-size station wagon, or when the angle between the transmission and differential is large, a two-piece drive shaft is used. This drive shaft, shown in Figure 8-5, uses two separate drive shafts. There is a universal joint at each end of the shaft as well as one in the center.

This type of shaft often uses a **center support.** The center support is mounted to the automobile chassis. A bearing assembly in the support is mounted to the drive shaft. A rubber bushing fits between the bearing and the mount. The center support holds the drive shaft in position and prevents whipping or vibration. Several styles of center supports are shown in Figure 8-6.

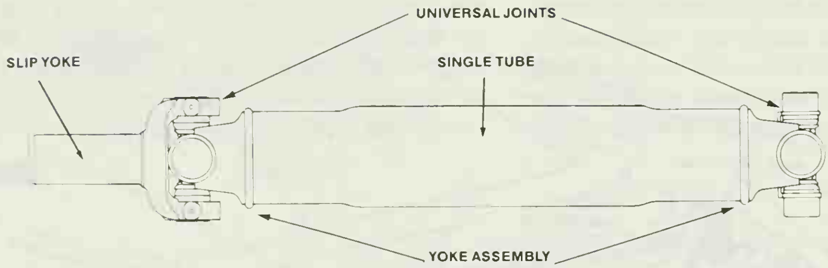


Figure 8-4. A single tube drive shaft with universal joints at each end. (Buick Motor Division of General Motors Corporation)

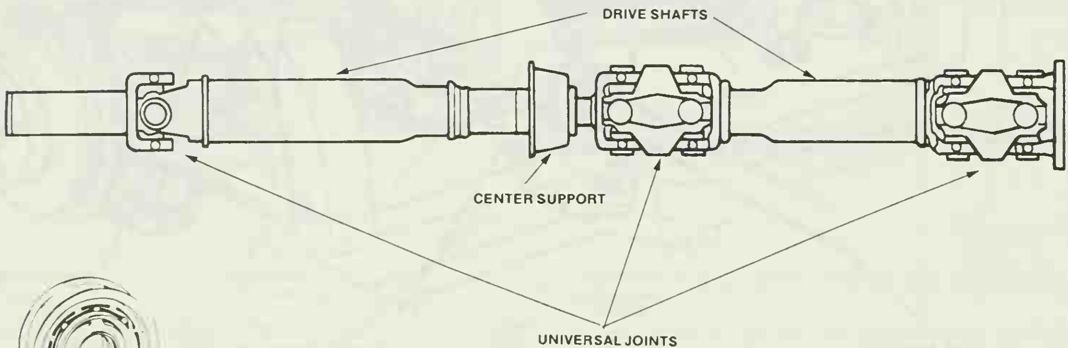


Figure 8-5. A drive shaft assembly with two separate shafts separated by a universal-joint and center-support assembly. (Cadillac Motor Car Division of General Motors Corporation)

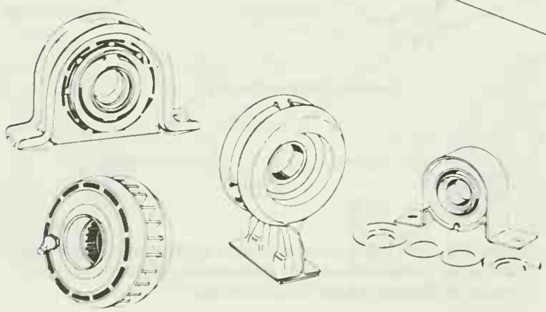


Figure 8-6. Various styles of center supports used to support the center of a drive shaft. (TRW)

Most drive shafts have a tendency to vibrate because of the universal joint action and other factors. Different methods have been used to eliminate the vibration in the tube. Cardboard tubes are sometimes pressed into the steel tubes. Some drive shafts have three rubber elements molded on the outside of the smaller diameter steel tube and then three of these units pressed into the drive shaft tube. A third type of drive shaft has one yoke welded to a smaller tube which has rubber elements molded to the outside. This assembly, shown in Figure 8-7, is then pressed into the drive shaft tube.

UNIVERSAL JOINT

The universal joint is basically two Y-shaped yokes connected by a crossmember called a cross or spider. The cross is shaped like an X, and the arms that extend from it are called trunnions. The yokes are free to move up and down in relation to the cross. This allows torque to be transferred through the universal joint when the yokes are positioned at an angle to each other. A simplified universal joint is shown in Figure 8-8.

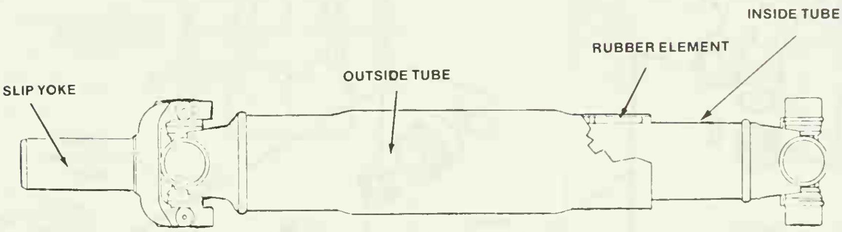


Figure 8-7. A two-piece drive shaft tube separated by a rubber element. (Buick Motor Division of General Motors Corporation)

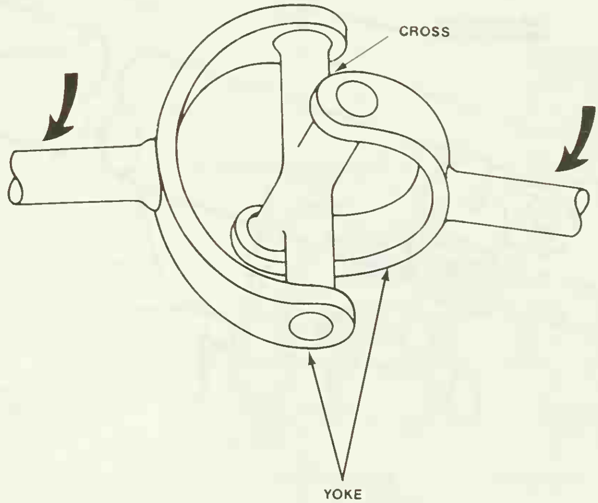


Figure 8-8. A simplified universal joint. (Chevrolet Motor Division of General Motors Corporation)

On the typical two universal drive shafts the front and rear universal joints are similar in construction and operation. Needle roller bearings support the cross or spider in the yokes. The bearing outer cup is deep enough to hold a reserve supply of lubricant. A seal is used between the cup and cross to hold the lubricant. An exploded view of a drive shaft assembly with two universal joints is shown in Figure 8-9.

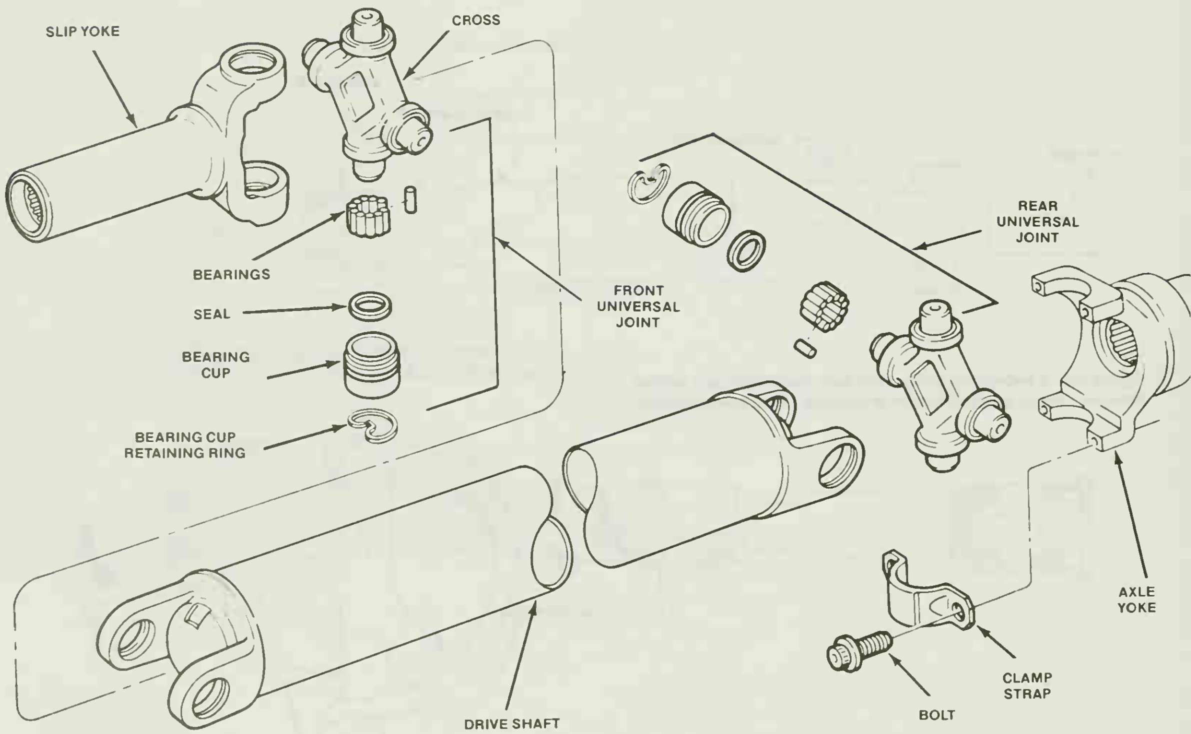


Figure 8-9. Exploded view of a drive shaft and universal-joint assembly. (American Motors Corporation)

There are three general methods of retaining the bearing cup in the bore of the yokes. One is to use a Spicer-style snap ring, which fits in a groove in the outside of the yoke. The snap ring prevents the cup from coming out of the yoke. Other universals use a mechanic's or Detroit-style snap ring, which fits into a groove in the bearing cup. The groove is located on the inside of the cup so the snap ring prevents the cup from moving out of the yoke. These two styles of snap rings and their location are shown in Figure 8-10.

A newer method of retaining the cups is to inject plastic into grooves in the yoke and bearing cup. With this system there is a groove in the outside diameter of this round bearing cup which mates with another groove in the inside diameter of the yoke bearing bore. Once the grooves are aligned by seating the bearing cups against the ends of the cross, a plastic ring is injected-molded between them, through a hole in the yoke. This retains the bearing cup in the yoke. A universal joint with an injected-molded retainer is shown in Figure 8-11.

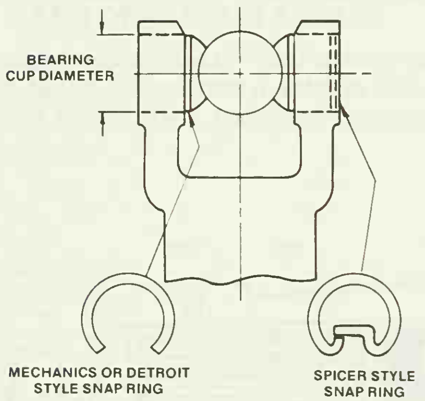


Figure 8-10. The two styles of snap rings and their location on a universal joint. (TRW)

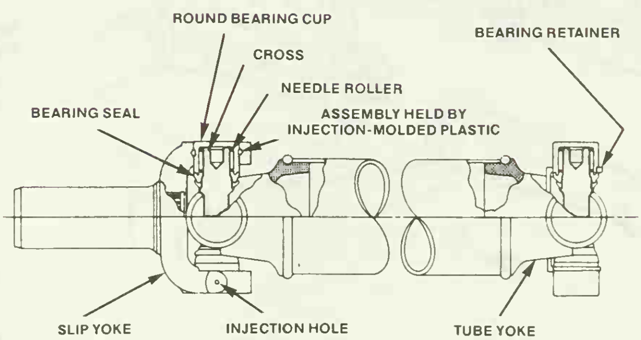


Figure 8-11. A universal-joint bearing assembly retained by an injection-molded plastic ring. (Chevrolet Motor Division of General Motors Corporation)

The universal-joint assembly is attached to the transmission output shaft through a slip-joint assembly. We will describe this unit in a later section. The attachment at the differential pinion shaft must be designed so that the drive shaft assembly can be detached and then pulled off of the transmission output shaft. There are two methods used to mount the universal assembly to the pinion flange. One is to use a strap and bolt to attach the drive shaft yoke to the pinion yoke. The other style uses a flange attached to the universal joint and the pinion. The two flanges are bolted together. These two attachment methods are shown in Figure 8-12.

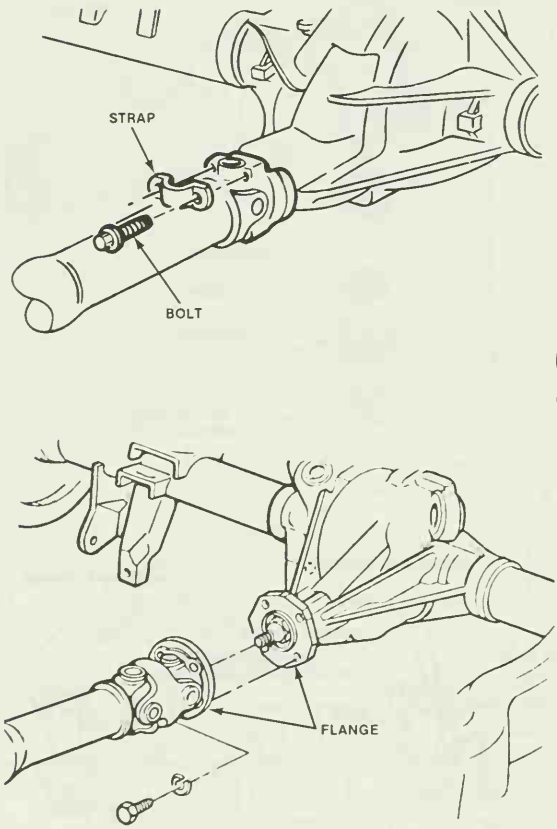


Figure 8-12. The two methods used to mount the universal joint to the pinion flange. (Chevrolet Motor Division of General Motors Corporation)

SLIP JOINTS

When the car goes over bumps, the differential is moving up and down on the suspension system. As it does so, the distance between the transmission and the rear axle is continually changing. The front yoke of the universal is connected to a slip joint. The slip joint will move in and out on the transmission shaft to make up for this change of distance. The slip joint is splined to the external splines of the transmission output shaft as shown in Figure 8-13. This is why the drive shaft is not anchored at the front. The spline of the slip joint fits snugly to the transmission output shaft and is free to move in and out as necessary.

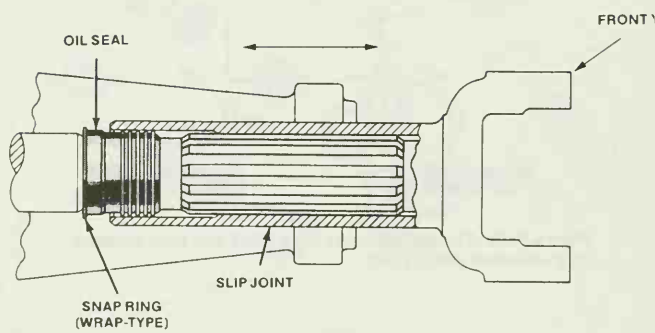


Figure 8-13. A slip joint allows for changes in drive line length. (Ford Motor Company)

On a manual-shift transmission, the slip joint spline is lubricated by the transmission's lubricant. This type of lubricant permits the slip joint to move in and out under all driving conditions. A lip seal in the transmission housing rides on the slip yoke and prevents lubricant from leaking out of the transmission.

Some automobiles use a yoke that has a roller bearing spline. With this yoke, the transmission **output shaft** has two grooves or keyways in which the two roller bearings fit around keys attached to the yoke. The roller bearings transmit the torque from the yoke to the shaft. As the yoke moves back and forth, the bearing rollers circulate around the machined keys and reduce the friction between the yoke and output shaft.

UNIVERSAL-JOINT INSTALLATION AND OPERATING ANGLES

The transmission and the rear axle housing are installed in the car at a definite angle in relation to the car's frame or underbody structure. The transmission and rear axle housing installation angles are shown in Figure 8-14. The transmission is rigidly attached to the car's frame and its installation angle changes only to the extent of the engine-transmission mount deflect. For our purposes, the **transmission installation angle** does not change during car operation. The differential housing is attached to the rear springs, which in turn are attached to the frame. The **differential housing installation angle** is, therefore, constantly changing with axle housing up and down movement and with differential housing rotation during braking and acceleration. The installation angle for the differential housing is, therefore, specified when the car is standing still and at curb weight.

When the transmission and differential housing installation angles and relative height with reference to the car's frame have been established, the drive shaft angles are also established.

The **universal-joint operating angle** is the angle formed by the crossing of the center lines of two drive line components which are coupled by a universal joint as shown in Figure 8-15. This angle is referred to as the

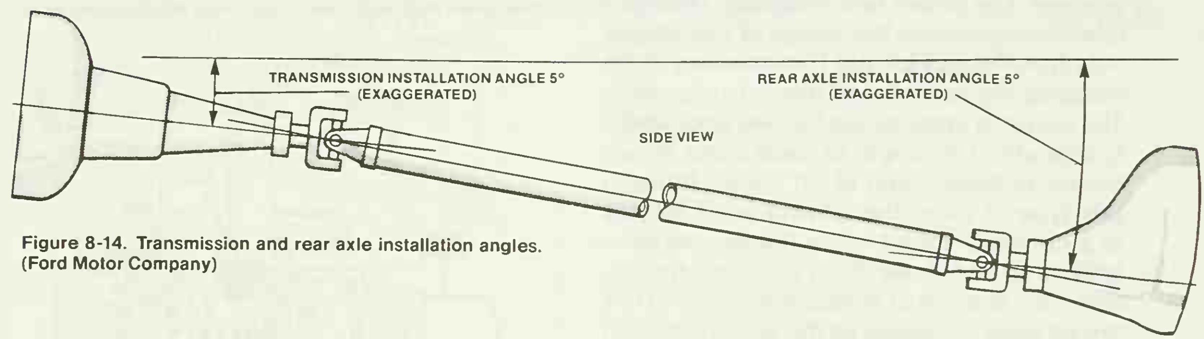


Figure 8-14. Transmission and rear axle installation angles. (Ford Motor Company)

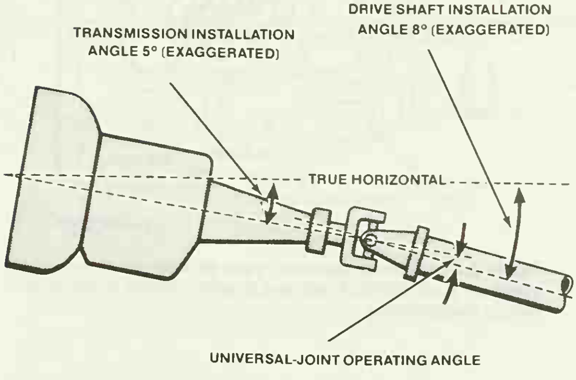


Figure 8-15. The transmission and drive shaft installation angles determine the universal-joint operating angle. (Ford Motor Company)

included angle. This angle cannot be measured directly. It must be calculated from the installation angles of the components which are coupled by the universal joint. If the components are tilted in the same direction, the universal-joint operating angle is the difference between the installation angles. If the components are tilted in opposite directions, the universal-joint operating angle is the sum of the installation angles. A universal-joint operating angle must be as small as possible because of its effect on universal-joint velocity.

UNIVERSAL-JOINT VELOCITY

Two universal joints are used in the typical Hotchkiss drive line. Two universal joints are required because the rear axle housing in normal driving moves up and down in relation to the vehicle's frame. This means that power flow through the drive line may change direction twice. For example, engine power flowing from the transmission output shaft to the drive shaft may change direction as it flows through the front universal joint. As the same engine power flows from the drive shaft to the drive pinion, it may again change direction, because the axle has moved up or down. The power flow may have changed directions, because the design of the vehicle may have called for the transmission to be installed higher or lower than the rear axle. The spider or cross allows the two yoke shafts to operate at an angle to each other. When torque is transmitted at an angle, through this type of joint, the driving yoke rotates at a constant speed while the driven yoke speeds up and slows down twice per revolution. This change of speed or velocity of the driven yoke increases as the angle between the two yoke shafts increases.

When the universal joints must operate on very large angles, a different type of universal joint is required. This type of universal joint is called a constant-velocity universal joint.

CONSTANT-VELOCITY (CV) UNIVERSAL JOINTS

As mentioned previously, the simple universal joint will operate efficiently through small angles. When a large angle is encountered in a drive line, a simple universal joint will introduce two vibrations in each revolution. It is in this situation that a **constant-velocity universal joint** is used.

Essentially, the constant-velocity or **double universal joint** is two simple universal joints closely coupled by a **coupling yoke,** phased properly for constant velocity. A simplified constant velocity joint is shown in Figure 8-16.

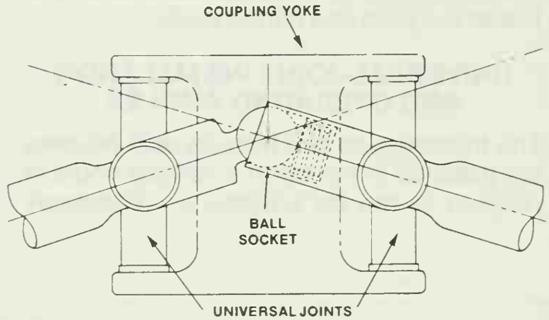


Figure 8-16. A simplified constant-velocity universal joint. (GMC Truck and Coach Division of General Motors Corporation)

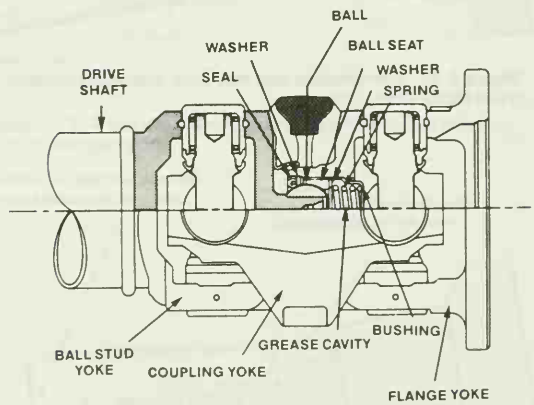


Figure 8-17. A cross-sectional view of a constant-velocity universal joint. (GMC Truck and Coach Division of General Motors Corporation)

A centering ball socket between the joints maintains the relative position of the two units. This centering device causes each of the two units to operate through one half of the complete angle between the drive shaft and differential carrier.

The component parts used in the constant-velocity universal joint are essentially the same as in two simple universal joints. The main difference is the coupling yoke and centering ball socket. The coupling yoke, also called a coupling link, is attached to the two universal joints with snap rings similar to a standard yoke arrangement. The centering ball fits on a **journal** which is attached to one of the shaft yokes and rides in a socket attached to the other yoke. A centering spring holds the centering ball in position. The coupling yoke and centering ball assembly are shown in cross section in Figure 8-17 and exploded view in Figure 8-18.

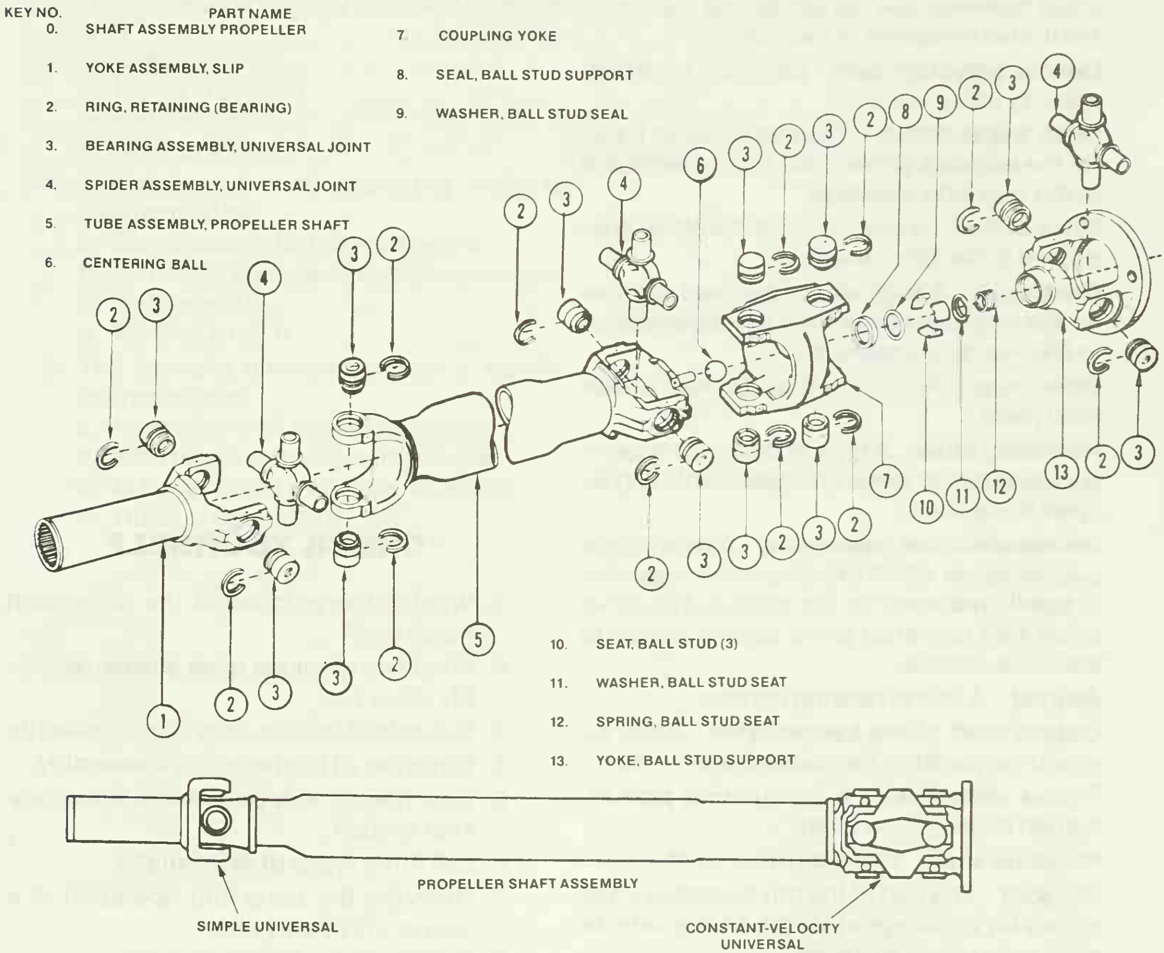


Figure 8-18. Exploded view of a drive shaft assembly with a simple universal at the front and a constant-velocity joint at the rear. (Cadillac Motor Car Division of General Motors Corporation)

NEW TERMS

Center support A bearing assembly mounted around the drive shaft and attached to the vehicle chassis to support the drive shaft.

Constant-velocity (CV) universal joint A universal joint constructed from two universal joints connected by a centering yoke and used when the operating angle is too large for a single universal joint.

Coupling yoke A component used to connect parts to a universal joint assembly.

Differential housing installation angle The angle between true horizontal and the pinion shaft when installed in the vehicle.

Double universal joint Same as constant-velocity universal joint.

Drive line assembly The parts used to transfer the engine's power from the transmission to the rear axle assembly.

Drive pinion A gear in the differential connected to the drive shaft.

Drive shaft A large steel tube used to transfer the engine's power from the transmission to the rear axle assembly.

Drive yoke A part used to connect power train parts.

Hotchkiss drive A type of drive line assembly using two or three universal joints and an open drive shaft.

Independent rear suspension A type of rear suspension in which the differential assembly is solidly mounted to the chassis and drive axles with universal joints deliver power to the drive wheels.

Journal A round bearing surface.

Output shaft of the transmission Shaft on which torque from the transmission exits.

Pinion shaft yoke A connecting part attached to the pinion shaft.

Propeller shaft Same as drive shaft.

Slip joint The part of the drive assembly that allows for a change in length as the vehicle goes over rough surfaces.

Torque tube drive A type of drive assembly that has the drive shaft enclosed in a tube called a torque tube.

Transmission installation angle The angle between true horizontal and the transmission output shaft when installed in the vehicle.

Universal joint The part of the drive line assembly that allows for a change in angle of the drive line as the differential moves up and down.

Universal-joint operating angle The angle the universal joint operates on determined by the differential and transmission operating angles.

CHECK YOURSELF

1. What is the purpose of the drive shaft assembly?
2. What two changes must a drive assembly allow for?
3. Describe a torque tube drive assembly.
4. Describe a Hotchkiss drive assembly.
5. Describe an independent rear suspension system.
6. List three types of drive shafts.
7. Describe the parts and operation of a simple universal joint.
8. Explain how a slip joint works.
9. How is a universal-joint operating angle determined?
10. Describe the parts and operation of a constant-velocity universal joint.

CERTIFICATION PRACTICE

1. Drive shaft angle and length changes are accomplished by:
   a. Universal joint
   b. Slip joint
   c. Both a and b
   d. Neither a nor b
2. The drive shaft may use:
   a. One universal joint
   b. Two universal joints
   c. Three universal joints
   d. All the above
3. Universal joint bearing cups are retained with:
   a. Snap rings
   b. Plastic injection
   c. Both a and b
   d. Neither a nor b
4. The universal joint operating angle is determined by:
   a. Transmission installation angle
   b. Differential housing installation angle
   c. Both a and b
   d. Neither a nor b
5. The velocity change through a simple universal joint:
   a. Increases with operating angle
   b. Decreases with operating angle
   c. Is not affected by operating angle
   d. None of the above

ANSWERS:

1.c, 2.d, 3.c, 4.c, 5.a

DISCUSSION TOPICS AND ACTIVITIES

1. Identify the parts of a drive assembly on a shop chassis. Can you explain the operation of all the parts?
2. Study a shop constant-velocity and single universal joint. What are the differences?

Unit 9
Drive Shaft Assembly Service

The drive shaft assembly is subjected to severe loading and unloading each time the vehicle is accelerated or decelerated. These stresses eventually lead to drive assembly wear. Drive line problems usually show up as a vibration that is especially bad on deceleration or as a noise that occurs as the vehicle begins to move from a stop. In this unit we will present the maintenance, troubleshooting, and service procedures used on drive shaft assemblies.

Preventive Maintenance

Troubleshooting

Service

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

9-1 Lubricate a universal joint.
9-2 Inspect a drive shaft assembly for wear.
9-3 Check a drive shaft for runout.
9-4 Measure and adjust universal-joint operating angle.
9-5 Balance a drive shaft.
9-6 Overhaul a simple universal joint.
9-7 Overhaul a constant-velocity universal joint.
9-8 Remove and replace a drive shaft center support bearing.

JOB COMPETENCY 9-1
LUBRICATE A UNIVERSAL JOINT

Preventive maintenance on the drive line assembly involves cleaning and inspecting the drive shaft and universal joints at regular intervals. Normally the maintenance is done with the vehicle on a hoist during a lubrication service.

For many vehicles, relubricating the drive shaft universal joints is not recommended. Inspect the front and rear joints for external leakage or damaged seals. If you find external leaks or damage, replace the universal joint as described later in this unit.

Some universal joints have a lubrication fitting in the cross (Figure 9-1). These units may be lubricated during a regular chassis lubrication. Use a low-pressure hand grease gun to lubricate the joint. Make sure the grease gun has the recommended type of grease. First wipe the lubrication fitting clean of grease and dirt. Select the proper size grease gun nozzle to fit on the grease fitting. Install the nozzle on the fitting and slowly pump grease into the joint. Stop when pressure builds up. Allowing grease to flow out of the joint can damage the grease seals and allow moisture to enter the bearings.

If the vehicle is operated under severe conditions and the universal joints do not have lubrication fittings, the universal joints should be disassembled, cleaned, and relubricated at intervals recommended by the manufacturer. We will describe this procedure later in this unit.

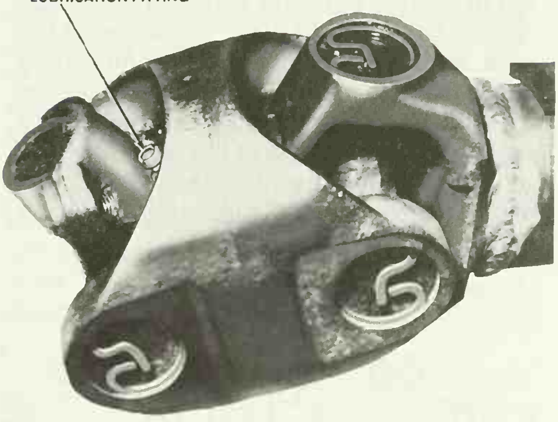


Figure 9-1. Some universal joints have a lubrication fitting for periodic lubrication. (GMC Truck and Coach Division of General Motors Corporation)

JOB COMPETENCY 9-2
INSPECT A DRIVE SHAFT ASSEMBLY FOR WEAR

When there is vibration on deceleration or clunks or squeaks during acceleration from a stop, inspect the drive shaft assembly. Raise the vehicle on a hoist and inspect the drive line components for the following conditions:

1. Undercoating or other foreign material on the drive shaft
2. Drive shaft balance weight missing
3. Broken seam welds in the drive shaft where yokes are welded to ends of the shaft tube
4. Dents, bends, or cracks in drive shaft tube
5. Loose, broken, or worn universal joints
6. Worn or damaged transmission extension housing or housing bushing
7. Pinion nut loose
8. Universal-joint clamp strap bolts loose or missing
9. Broken or loose engine front supports or rear crossmember
10. Broken or loose rear springs or broken or loose spring U-bolts
11. Rear axle spring mounting pads broken, cracked, or loose

Universal joint wear is most often shown by a squeak, clunk, or knocking noise when the automobile is accelerated. The problem usually shows up just after the transmission has been put into gear, either forward or reverse. The mechanic should drive the vehicle and listen for the noises in the drive line area.

A broken or worn universal joint may be too warm or loose. Place your hand near the universal and feel for heat. Overheating of the U-joint can signal a worn joint. Damaged seats can also be indicators of immediate or future U-joint problems. To check for worn U-joints, have someone move the transmission range selector from forward to reverse while firmly applying the brakes. Any motion, looseness, or play in the U-joint indicates a worn U-joint (Figure 9-2).

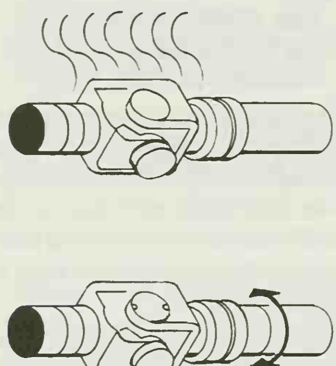


Figure 9-2. Worn universal joints may be overheated or loose. (TRW)

JOB COMPETENCY 9-3 CHECK A DRIVE SHAFT FOR RUNOUT

When drive shaft noise or vibration occurs at high speed, it could be caused by excessive **drive shaft runout** or wobble. Use the following procedure to check for drive shaft straightness.

Raise the car on a twin post hoist so that the rear of the car is supported on the rear axle housing with wheels free to rotate. Mount a dial indicator on a movable support that is high enough to permit contact of the indicator contact button with the drive shaft as shown in Figure 9-3.

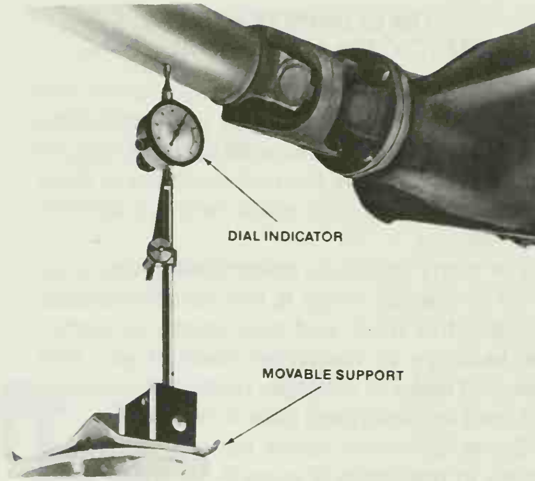


Figure 9-3. Drive shaft runout is measured with a dial indicator and a movable mount under the drive shaft. (Cadillac Motor Car Division of General Motors Corporation)

Take readings at several locations along the drive shaft as shown in Figure 9-4. Mark the shaft and pinion flange so you can find the original position after the checks are performed. With the transmission in neutral, check and record runout by having a second person turn the rear wheel slowly so that the drive shaft will rotate. Care must be taken not to include indicator variation caused by ridges, flat spots, or other variations of the tube. If runout at all of the places measured is less than the manufacturer's specifications for total indicator reading, the drive shaft is probably not the cause of the disturbance. If runout exceeds the manufacturer's specifications, reduce the runout by following these steps.

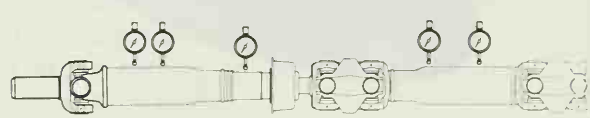


Figure 9-4. Typical areas used to check runout on a drive shaft assembly. (Cadillac Motor Car Division of General Motors Corporation)

Record runout at each location with the shaft in the original installed position. Index the shaft to the next position on the pinion flange and again check and record the runout at each location. Continue this procedure until the runout has been checked at all possible mounting positions. Check all runout figures recorded. If runout readings at all locations listed in one shaft position are less than .060 (1.52 mm), install the shaft in the vehicle in this position and road-test. If the disturbance is still objectionable, balance the shaft as described in a later section. If the amount of front end and middle runout in all shaft positions is over .060 (1.52 mm), replace the shaft.

JOB COMPETENCY 9-4 MEASURE AND ADJUST UNIVERSAL-JOINT OPERATING ANGLE

The angles through which the universal joints on each end of the drive shaft operate must be very nearly the same. If these angles are different, operation is rough and an objectionable vibration is produced. In addition, the universal joints are designed to operate safely and effectively within certain angles. If the design angle is exceeded, the joint may break or otherwise be damaged.

The front universal joint angle (A in Figure 9-5) is the angle between the transmission output shaft center line and the center line of the drive shaft which connects to it. This angle is determined by the design of the body assembly and is not likely to change. Therefore, it is rarely adjusted. The rear universal joint angle (B in Figure 9-5) is the angle between the center line of the drive shaft and the center line of the differential pinion shaft. This angle can change; if it does, it must be adjusted.

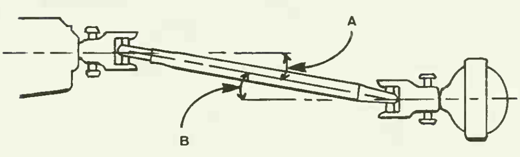


Figure 9-5. While the angle at A rarely changes, the angle at B may require adjustment. (TRW)

Operating angle gages are available for measuring the operating angles in the drive line (Figure 9-6). Following the procedure outlined by the manufacturer, mount the gage in the proper location and measure the angle. Compare the measurement to specifications to see if an adjustment is necessary.

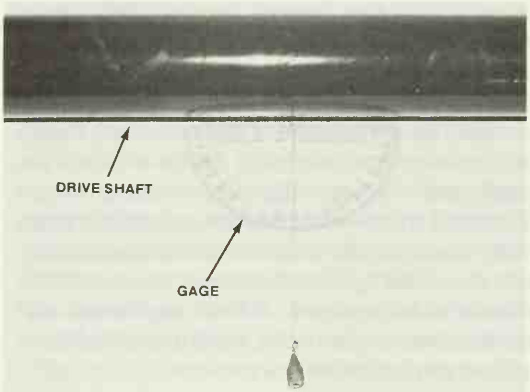


Figure 9-6. A protractor-type gage is used to measure drive shaft and universal-joint angles.

The adjustment is made by rotating the rear axle assembly. The method varies from car to car. On some cars you can lengthen or shorten the upper control arms with shims at the frame bracket ends. On other cars you can place shims between the rear spring and differential housing spring plate. One make of car has cam-type adjusters located at each rear upper control to the differential carrier attaching point. Refer to the manufacturer's service manual for the specific procedures for adjusting the drive shaft rear joint angle.

JOB COMPETENCY 9-5 BALANCE A DRIVE SHAFT

If troubleshooting indicates that a **drive shaft is out of balance**, it must be rebalanced. Electronic balancing equipment does a fast and accurate balance job. If this equipment is not available, you can balance the shaft mechanically.

Clean all undercoating and accumulated dirt from the shaft. Raise and support the rear of the automobile at the axle and remove the rear wheels. Operate the automobile in gear at approximately 40 mph to locate the

heavy side of propeller shaft. Use a jack stand as a steady rest and slowly advance a crayon or chalk toward the spinning propeller shaft. At the instant of first contact with the propeller shaft, withdraw the chalk or crayon. This mark indicates the heavy spot of the drive shaft.

Place two worm-type hose clamps on the drive shaft with heads located 180° from the heavy spot. Slide the clamps to the rear as far as possible, as shown in Figure 9-7. Operate the vehicle in gear at the vibration speed. If the vibration is not reduced, rotate both clamp heads at 90° steps around the shaft until the vibration is reduced. When the point of lowest vibration is found, rotate both clamp heads an equal distance in opposite direction toward the heavy spot until the vibration is reduced. If the results are not satisfactory, repeat the balance procedure at the front of the drive shaft.

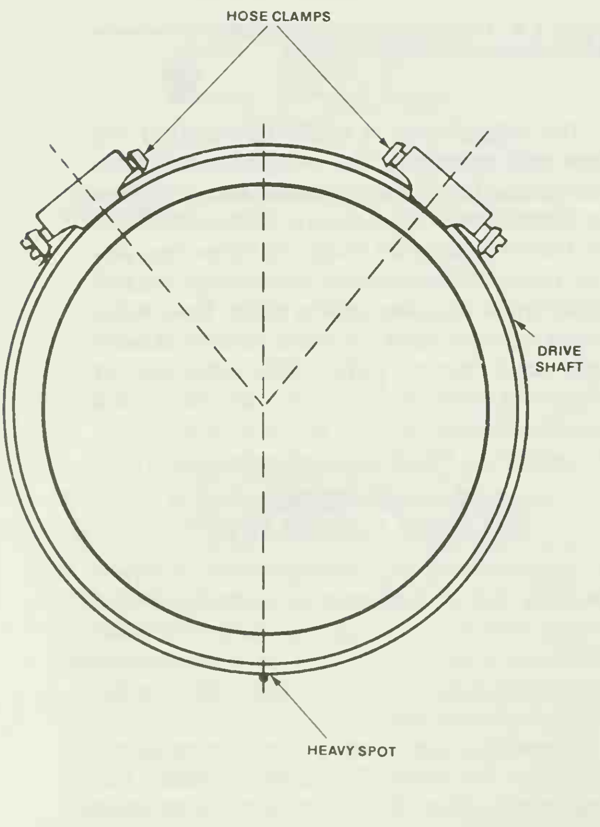


Figure 9-7. Hose clamps may be used to balance a drive shaft. (American Motors Corporation)

JOB COMPETENCY 9-6 OVERHAUL A SIMPLE UNIVERSAL JOINT

Universal joint service involves disassembling the universal joints and installing a repair kit. The repair kit shown in Figure 9-8 consists of a new cross, bearing cups, a washer, roller bearings, seals, and a bearing retainer. Raise the car on a twin post hoist or jack stands to provide access to the drive shaft. Remove the drive shaft by unbolting the flange or strap attachment at the rear axle end. Withdraw the drive shaft front yoke from the transmission by moving the shaft toward the rear passing it under the axle housing. Watch for oil leakage from the transmission output shaft housing.

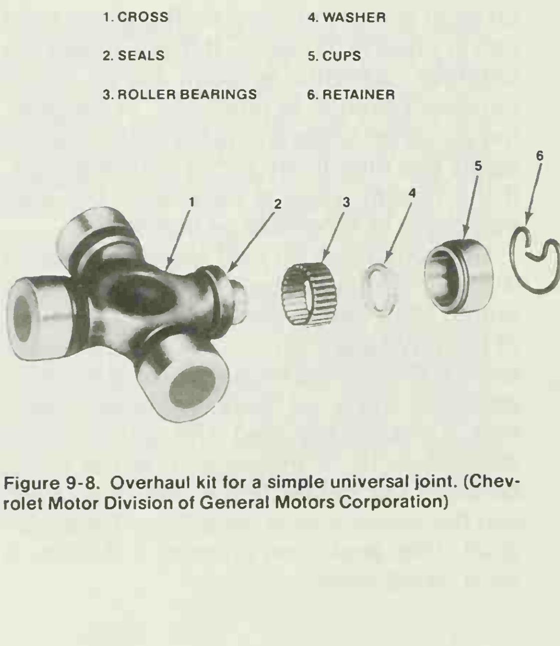


Figure 9-8. Overhaul kit for a simple universal joint. (Chevrolet Motor Division of General Motors Corporation)

Before you disassemble the universal joint, mark the yoke, cross, and bushings to help in reassembly if parts are serviceable. Drive shafts and U-joints are frequently factory balanced as a unit and, therefore, must be installed in the same position to maintain this balance. To be sure that you maintain this exact position, prior to disassembly scribe the shaft and yoke with locating marks. This will assure that the unit will be reassembled in proper phase and balance.

Remove the four bearing retainers from the universal joint cross assembly. Using a socket approximately the same diameter as the bearing cup, press one bearing assembly out of the yoke by pressing the opposite bearing in, Figure 9-9. Press out the remaining bearing and roller assembly by pressing on the end of the cross. Remove the cross assembly from yoke.

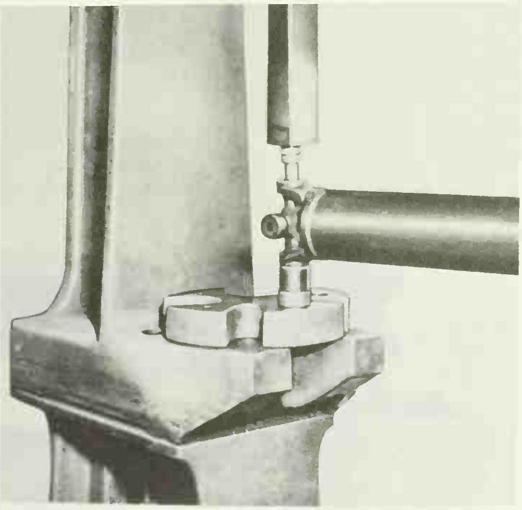


Figure 9-9. Removing a bearing assembly with a press and sockets. (Chevrolet Motor Division of General Motors Corporation)

Clean all parts in a suitable solvent and allow to dry. Examine bearing surfaces of the cross. They should be smooth and free from ripples and pits. If the bearing surfaces or seal retainers are damaged, replace the cross assembly. Examine rollers in the bearing cups. Rollers that have operated on a worn cross should be replaced. Rollers should look smooth and roll freely inside the cups.

Lubricate the bearing assemblies with a recommended lubricant. Also fill the reservoirs in the ends of the cross. Place the cross in the drive shaft yoke, observing identification marks made at disassembly. Install cup and roller assemblies in the yoke, matching identifying marks. Press both cup assemblies into the yoke while guiding the cross into the bearings. A vise or arbor press may be used (Figure 9-10). Correctly position bearings so retainers can be installed. As soon as one bearing retainer groove clears the inside of the yoke, stop pressing and snap the bearing retainer into place. Continue to press until the opposite bearing retainer can be snapped into place.

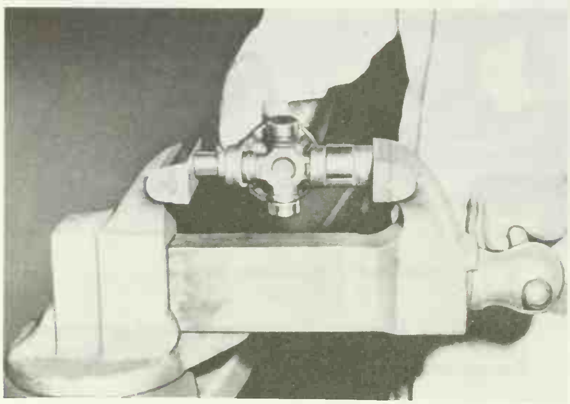


Figure 9-10. A vise may be used the press the bearing caps into the drive shaft yoke. (Chevrolet Motor Division of General Motors Corporation)

Assemble the other half of the universal joint in the same way. Check the freedom of rotation of both sets of bearing cups and trunnions of the cross.

Use extreme cleanliness and care during assembly. Make sure that fittings, flanges, yokes, sleeves, splines, and mating surfaces are clean and smooth. DO NOT USE EXCESSIVE FORCE. Too much force during assembly can damage parts and cause vibration and erratic performance.

Inspect the yoke seal in the transmission extension; if necessary replace it as described in the transmission unit. Apply a light coating of transmission oil to transmission splines. Insert the drive shaft front yoke into the transmission extension, making sure that the output shaft splines mate with the propeller shaft yoke splines. Align the drive shaft with the companion flange, using reference marks you made during removal. Connect the exposed bearing cups to the companion flange by installing the retaining strap and screws. Torque bolts to specifications. Lower the car and road-test.

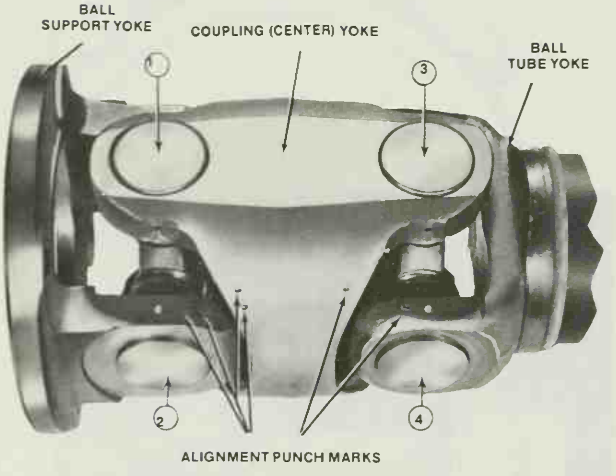


Figure 9-11. Alignment marks are punched or scribed on yokes prior to disassembly. (Cadillac Motor Car Division of General Motors Corporation)

JOB COMPETENCY 9-7 OVERHAUL A CONSTANT-VELOCITY UNIVERSAL JOINT

Raise the vehicle. Remove the drive shaft following the procedure described for a simple universal joint. As shown in Figure 9-11, scribe or punch alignment marks on all yokes for reassembly.

Remove rear trunnion snap rings from the center yoke. Remove the grease fitting. Place the drive shaft in a vise. Drive one rear trunnion bearing cup from the center yoke as shown in Figure 9-12 until it protrudes about ⅜". Keep the rear portion of the propeller shaft up to avoid interference of the rear yoke half with the center yoke. Once the bearing cup protrudes ⅜", release the vise. Grasp the protruding portion of the cup in the vise and strike the center yoke as shown in Figure 9-13 until cup is removed. Remove the cup seal by prying it off with a thin screwdriver. Repeat this procedure for the other bearing cup.

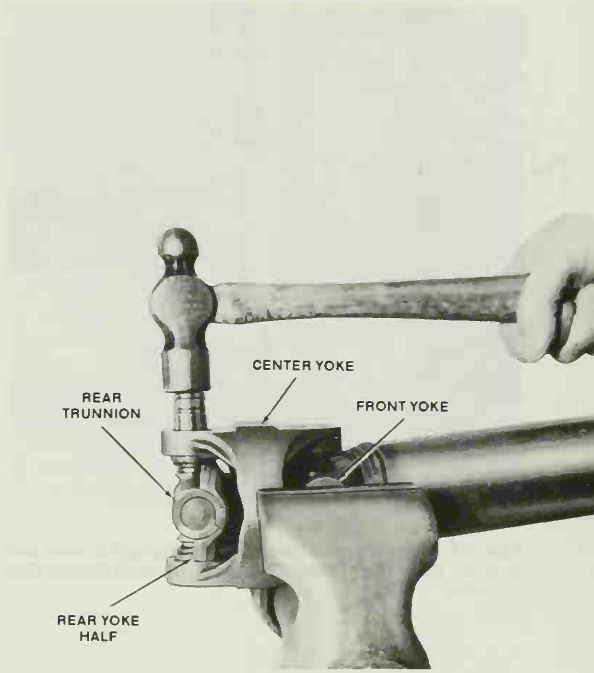


Figure 9-12. Driving out constant-velocity bearing cups. (General Motors Corporation)

After you remove the center yoke cups, remove the rear yoke half bearing cups. Remove the rear trunnion. Gently pull the rear yoke half from the drive shaft. Remove all loose needle bearings. Remove the spring seal. Remove the front trunnion from the center and front yoke in the same manner as described above. Before the front trunnion can be removed, all four bearing cups must be removed. Servicing and inspection of the trunnion and bearing cups is the same as that described for simple universal joints.

When both bearing cups are free, disengage the flange yoke and trunnion from the centering ball. Note that the ball socket is part of the flange yoke assembly, while the centering ball is pressed onto a stud and is part of the ball stud yoke. Pry the seal from the ball socket and remove washers, the spring, and the three ball seats as illustrated in Figure 9-14.

Clean and inspect the ball seat insert bushing for wear. If the bushing is worn, replace the flange yoke and cross assembly. Clean and inspect the seal and ball seats along with the spring and washers. If any parts show excessive wear or are broken, replace the entire set with a service kit. Whenever you remove the seal to inspect the ball seat parts, discard and replace it with a new seal. Remove all plastic from the groove of the coupling yoke. Inspect the centering ball surface. If it shows signs of wear beyond smooth polish, replace it.

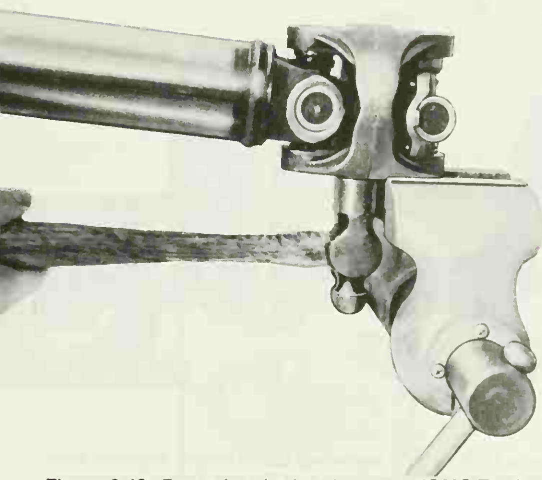


Figure 9-13. Removing the bearing cups. (GMC Truck and Coach Division of General Motors Corporation)

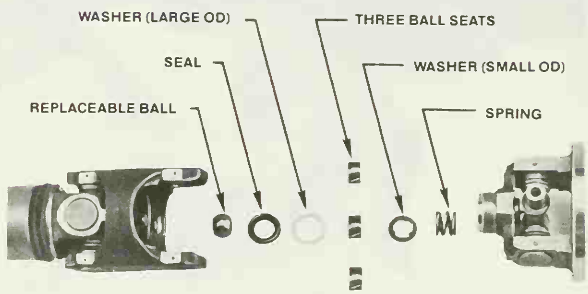


Figure 9-14. Parts of the centering ball assembly. (GMC Truck and Coach Division of General Motors Corporation)

Remove the centering ball with a special puller. The fingers on the tool fit under the ball. A nut on the tool pulls the ball off as shown in Figure 9-15. Use a driver to drive the replacement ball into position as shown in Figure 9-16. Drive the ball onto the stud until the ball seats firmly against the shoulder at the base of the stud. This is important because the center of the constant velocity joint depends on the ball seating tightly in the proper place.

Using grease provided in the ball seat kit, lubricate all parts and insert them into the clean ball seat cavity in the correct order. Lubricate the seal lip and press in a new seal. Fill the cavity with grease provided in the kit. Install the flange yoke to the centering ball making sure alignment marks are correctly positioned.

Clean and inspect all needle bearings, cups, seals, the grease fitting, trunnions, and yokes. Assemble all needle bearings in cups; assemble seals to bearing cups.

Place the front trunnion in the drive shaft. Place the center yoke on the front trunnion. Install one bearing cup assembly in the front yoke. Drive it deep enough so that the snap ring can be installed. Install the snap ring. Install the remaining cup in the front yoke. Install the snap ring. Install front trunnion bearing cups in the center yoke in the same manner. Insert the rear trunnion in the center yoke. Install the rear yoke half bearing cups on the rear trunnion. Install one rear trunnion bearing cup in the center yoke and press into the yoke until the snap ring can be installed. Install the remaining cup and snap ring. Grease the centering ball. The lubrication fitting for the centering ball requires a needle style nozzle. Install the drive shaft. Lower the vehicle and road-test.

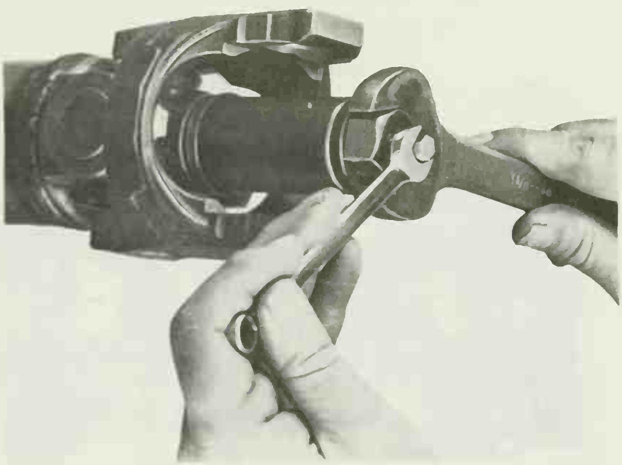


Figure 9-15. The centering ball is removed with a special puller. (GMC Truck and Coach Division of General Motors Corporation)

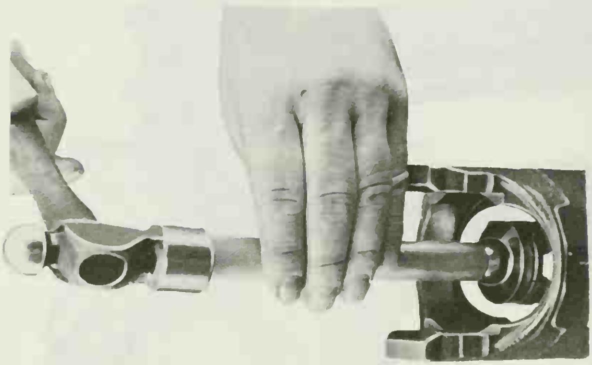


Figure 9-16. A new centering ball is driven onto the stud. (GMC Truck and Coach Division of General Motors Corporation)

JOB COMPETENCY 9-8 REMOVE AND REPLACE A DRIVE SHAFT CENTER SUPPORT BEARING

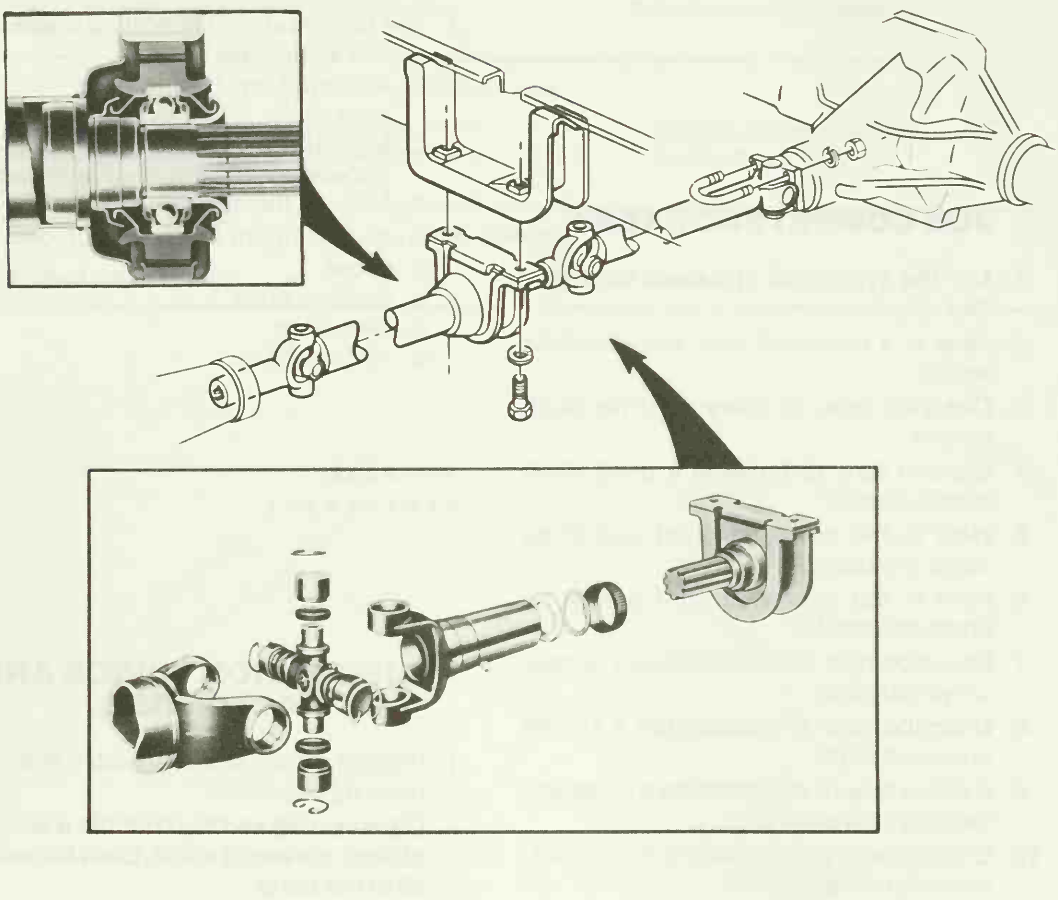
When it is necessary to remove a center support bearing, raise the vehicle on a twin post hoist or jack stands. Remove the drive shaft as described previously. Refer to Figure 9-17 which shows the parts of a typical center support bearing assembly.

Remove the strap retaining the rubber cushion from the bearing support. Pull the support bracket from the rubber cushion and pull the cushion from the bearing. Pull the bearing assembly from the shaft. Remove and discard the center bearing lock retainer if it is damaged. Remove the center slip-yoke seal, split washer, and center bearing retainer nut from the slip yoke. Inspect for damage or excessive wear.

Check to make sure that the replacement bearing assembly is the same as the old one. Start the bearing and slinger assembly straight on the shaft journal. Support the propeller shaft and, using a suitable length of pipe over the splined end of the shaft, press the bearing and inner slinger against shoulder on the shaft. Install the dust shield over the shaft. Install the bearing retainer. Install the rubber cushion onto the bearing and the bracket onto the cushion. Install the retaining strap.

Replace the drive shaft and lower the vehicle. Road-test the car to check for proper operation.

Figure 9-17. Parts of a center-support bearing assembly. (GMC Truck and Coach Division of General Motors Corporation)



NEW TERMS

Drive shaft out of balance A condition caused by a bent, dirty, or undercoated drive shaft that shows up as a vibration.

Drive shaft runout A condition in which the drive shaft wobbles as it turns.

Operating angle gage A protractor tool used to measure the universal-joint operating angle.

JOB COMPETENCY TEST

1. List the symptoms of a drive assembly that requires service.
2. How is a universal joint inspected for wear?
3. Describe how to measure drive shaft runout.
4. Explain how to balance a drive shaft mechanically.
5. How is the universal joint operating angle measured?
6. How is the universal joint operating angle adjusted?
7. Describe how to disassemble a simple universal joint.
8. Describe how to reassemble a simple universal joint.
9. Explain how to disassemble a constant-velocity universal joint.
10. Explain how to reassemble a constant-velocity universal joint.

CERTIFICATION PRACTICE

1. Mechanic A says an out-of-balance drive shaft vibrates on deceleration.
   Mechanic B says an out-of-balance drive shaft vibrates on acceleration.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. A drive shaft may be out of balance from:
   a. Dents
   b. Undercoating
   c. Missing weight
   d. All the above
3. A worn universal joint may be:
   a. Loose
   b. Overheating
   c. Both a and b
   d. Neither a nor b
4. The universal joint operating angle is:
   a. Not adjustable
   b. Adjusted by rotating the rear axle housing
   c. Adjusted by raising or lowering the transmission
   d. None of the above
5. A universal-joint repair kit includes:
   a. Cross
   b. Bearing cups
   c. Retainers
   d. All the above

ANSWERS:

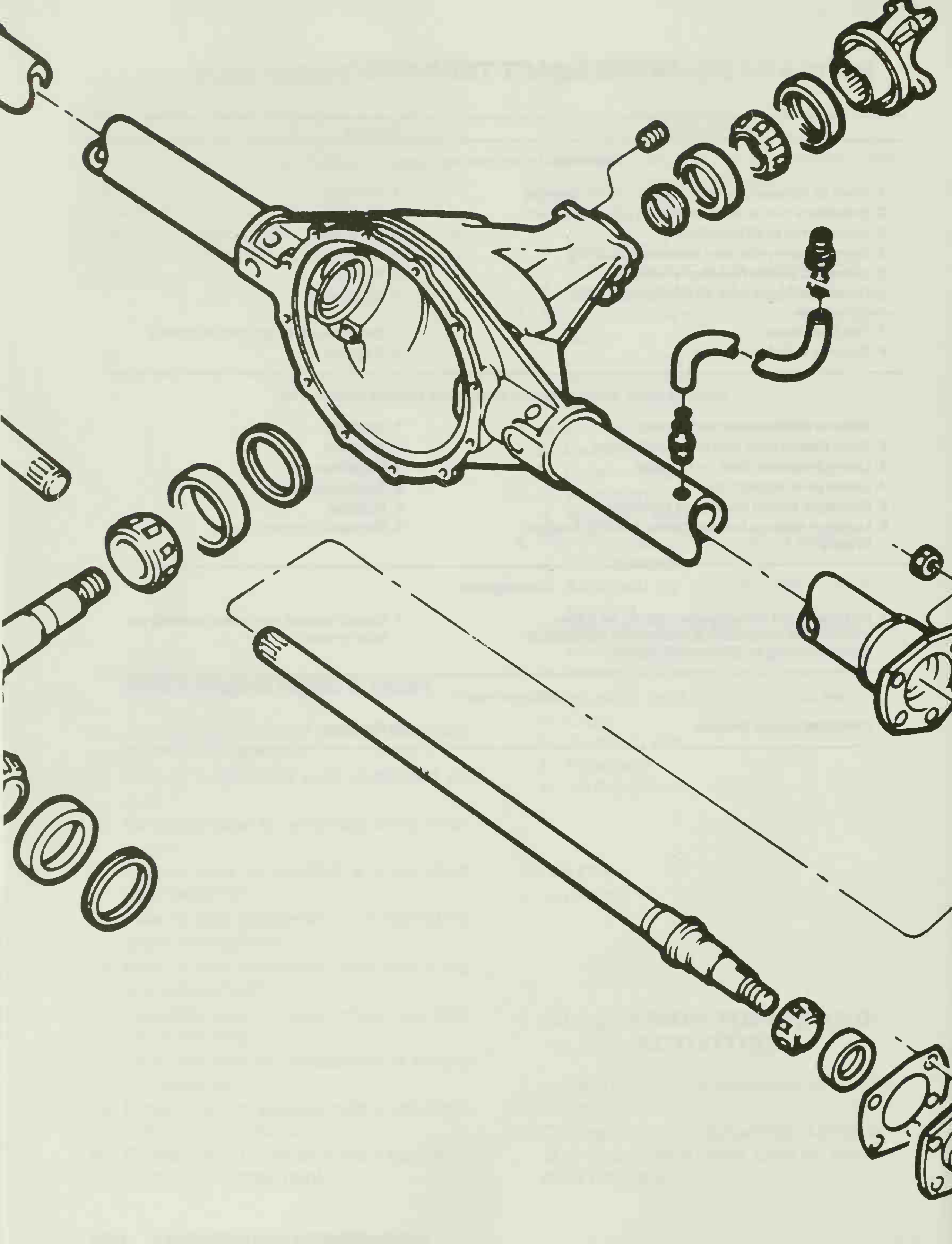
1.a, 2.d, 3.c, 4.b, 5.d

DISCUSSION TOPICS AND ACTIVITIES

1. Inspect a drive shaft assembly and determine its condition.
2. Disassemble and reassemble a selection of shop universal joints. Look for wear on all of the parts.

DRIVE SHAFT TECH CHECK

Possible Cause	Service
Vibration at medium or high speed	
1. Worn or damaged universal joint needle bearing	1. Replace
2. Imbalance due to bent or dented propeller shaft	2. Replace
3. Loose drive shaft installation	3. Retighten
4. Worn transmission rear extension bushing	4. Replace
5. Damaged center bearing or insulator	5. Replace
6. Undercoating or mud on the shaft causing imbalance	6. Clean shaft
7. Tire imbalance	7. Balance wheel and tire assembly
8. Balance weights missing	8. Replace
Knocking sound during starting or noise during coasting on drive shaft	
1. Worn or damaged universal joint	1. Replace
2. Worn sleeve yoke and mainshaft spline	2. Replace
3. Loose propeller shaft installation	3. Retighten
4. Loose joint installation	4. Adjust snap ring
5. Damaged center bearing or insulator	5. Replace
6. Loose or missing bolts at center bearing bracket to body	6. Replace or tighten bolts
Scraping noise	
1. Dust cover on sleeve yoke rubbing on transmission rear extension; dust cover on companion flange rubbing on differential carrier	1. Straighten out dust cover to remove interference
Whine or whistle	
1. Damaged center bearing	1. Replace



Unit 10
Differential Assembly

The **differential** assembly is a system of gears located in a separate housing or in the same housing used for the transmission gears. The differential performs several important functions. First, it takes the torque developed by the engine and increases it three to four times through gearing. Second, the differential divides the torque and directs it to each of the two driving wheels. Finally, it is designed to allow each of the driving wheels to turn at different speeds. The differential gets its name from the fact that it allows the driving wheels and axles to turn at different or differential speeds.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe the basic parts and operations of a differential.
2. Identify the main components of a differential.
3. Explain the types of gears and gear ratios used in a differential.
4. Describe the operation of a multiple disc and cone-type limited-slip differential.
5. Identify the different types of differentials in use.

BASIC DIFFERENTIAL PARTS AND OPERATION

When a vehicle is travelling in a straight line, the driving wheels turn at the same speed. When we make a left or right turn, the wheels must turn at different speeds. In Figure 10-1

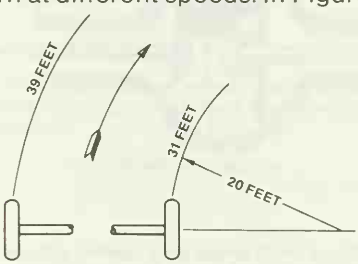


Figure 10-1. The driving wheels turn at different speeds when going around a corner. (GMC Truck and Coach Division of General Motors Corporation)

a set of driving wheels is shown travelling through a right turn. The outside wheel has farther to travel. If both of the wheels turned at the same speed, the tires would scuff and slide around the corner. The differential is designed to allow the outside wheel on a turn to go faster than the inside wheel.

In order to let the wheels turn at different speeds, several basic parts are necessary. First there are two axles, each with a wheel on one end and a gear on the other end. The gears are small spur bevel gears and are called differential gears or **side gears.** The differential case is shown in Figure 10-2 as a crooked bar fastened around one of the axles. It is loose on the axle, however, so it can turn around on it. In the case is mounted a pinion shaft and two **differential pinions.** (One pinion gear is shown for simplicity.) Pinion gears are small bevel gears which fit in between the two side gears and mesh with both of them as shown in Figure 10-3.

Two more gears complete the unit. One is a gear called the drive pinion. The drive pinion is usually supported on two large bearings mounted to the housing. The drive pinion gear is meshed with the other gear called the **ring gear**, which is mounted to the **case.** The case, in turn, is mounted on bearings. This allows the drive pinion to turn the ring gear and case. The ring and pinion gear added to the differential are shown in Figure 10-4.

When we are going straight ahead on a smooth road, the wheels should be turning at the same speed. Engine power is driving the ring gear, so the case is going around, carrying the pinion shaft with it. This turns the two side gears, and the whole mechanism revolves as one solid unit as shown in Figure 10-5. The gears are not turning on one another. The pinions are simply connecting the two side gears together; they could just as well be bolted together solidly. They are turning at the same speed as the

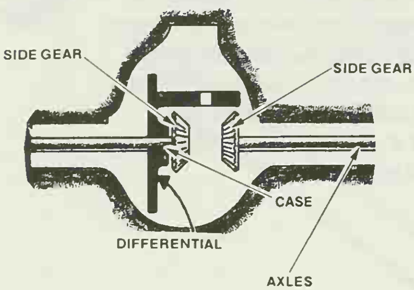


Figure 10-2. Each axle has a side or differential gear attached to it. (GMC Truck and Coach Division of General Motors Corporation)

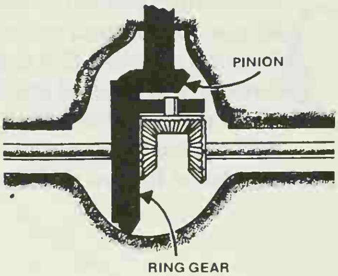


Figure 10-4. A drive pinion gear is in mesh with a ring gear attached to the carrier. (GMC Truck and Coach Division of General Motors Corporation)

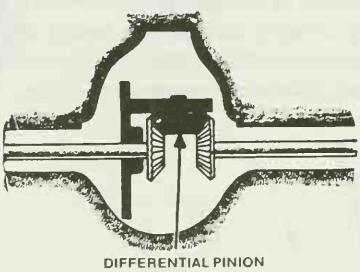


Figure 10-3. A small pinion gear meshes with the two side gears. (GMC Truck and Coach Division of General Motors Corporation)

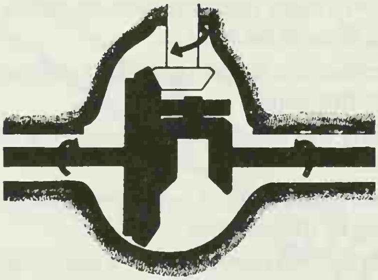


Figure 10-5. When going straight ahead, everything turns together. (GMC Truck and Coach Division of General Motors Corporation)

differential. It is as if there were no differential at all. The wheels are travelling together, and a differential is not needed.

Now let's hold one wheel so it cannot turn. The case is turned as before, again carrying the pinion shaft with it. But one axle is held, so its side gear cannot go around. Therefore, the pinion gears must revolve on the pinion shaft. The pinion gears are being carried around by the case, but at the same time they are revolving around on their own short shaft. They must revolve in order to stay meshed with the stationary side gear. They are running around the stationary gear.

The other side gear is meshed with the pinion, too, but it is free to turn. It is being turned just the same as it was in the first case, but in addition it is being turned more by the revolving of the pinion on its own shaft as shown in Figure 10-6. The pinion is revolving in the right direction so that its motion is added to the movement of the differential case. The second side gear is turning faster than before. In fact this axle and wheel are turning exactly twice as fast as when the two wheels were running at the same speed.

Now let's see what happens when both wheels are turning, but one is going faster than the other. This is the case when an automobile turns a corner. The inside wheel travels a shorter distance than the outside wheel; therefore, it must turn around more slowly.

The inside wheel and the differential gear on its axle shaft are revolving more slowly than the differential. The differential gear is turning more slowly than the pinion is being carried around. So we have the same effect as when the axle shaft was held tight—the pinion must turn on its own shaft. It will not turn as fast as before, but it will turn as shown in Figure 10-7. And it again turns in a direction to add to the speed of the opposite differential gear. The pinion adds to the differential gear exactly the amount taken away from the slower differential gear.

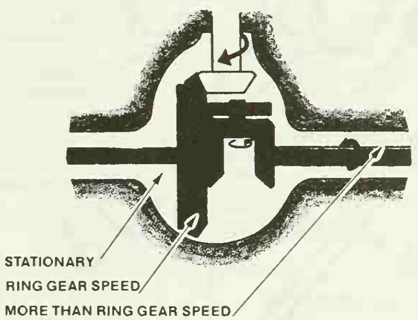


Figure 10-6. When one wheel is stationary, the other one turns more slowly. (GMC Truck and Coach Division of General Motors Corporation)

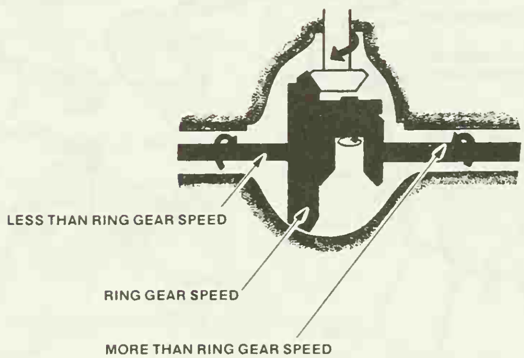


Figure 10-7. During a turn, one wheel speeds up and the other slows down. (GMC Truck and Coach Division of General Motors Corporation)

For example, suppose the differential is being driven at 500 revolutions per minute. Then if the inside wheel is turning at 400 rpm, the outer one must be turning at 600 rpm. If one is turning at 490 rpm, the other is 510 rpm. And in the extreme case we had, if one is standing still, which is 0 rpm, the other turns at 1,000 rpm. That is how a differential must work—what is subtracted from one side must be added to the other. The ring gear speed always splits the difference between the two.

DIFFERENTIAL COMPONENTS

In the last section we described the operation of a basic differential. In this section we will take a closer look at each of the components of a differential. An exploded view of a differential is shown in Figure 10-8.

All the differential parts are mounted in a housing. The housing, sometimes called the **carrier**, is made of cast iron or aluminum. The drive pinion gear is mounted in the housing. The drive pinion gear has a shaft formed on it. The shaft is used to drive the pinion gear and support it in the housing. As shown in Figure 10-9, the drive pinion is usually supported in its housing on two tapered roller bearings. One, called the rear bearing, fits just behind the pinion gear. The other, called the front bearing, fits at the other end of the shaft. Races for the bearings are pressed into the housing. A spacer fits between the two bearings on the shaft.

An oil seal and oil slinger prevent lubricant in the housing from leaking out around the pinion shaft. The seal is mounted into the the housing and fits around the pinion shaft.

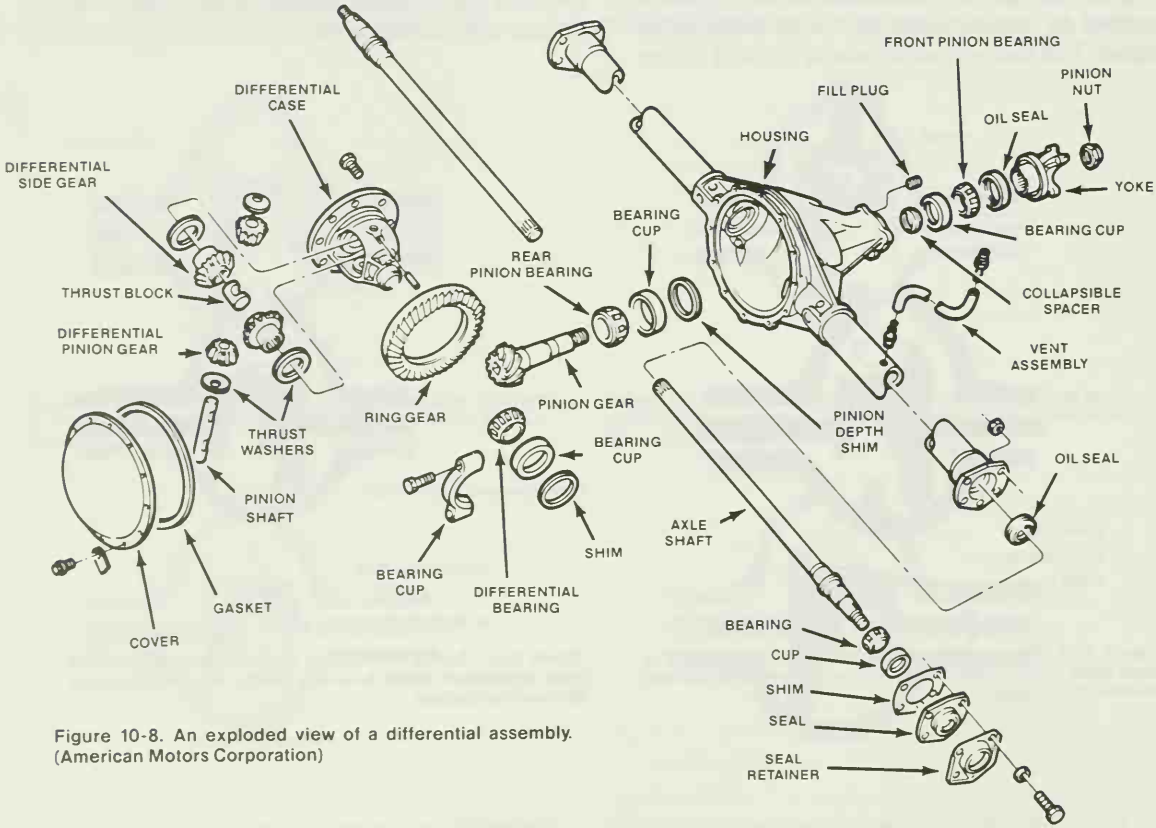


Figure 10-8. An exploded view of a differential assembly. (American Motors Corporation)

Splines on the end of the pinion shaft allow it to be connected to a companion flange. Splines in the companion flange slip over the splines on the pinion shaft. The companion flange is connected to the transmission or drive shaft to deliver engine power to the drive pinion. A nut and washer are used to hold all these components in the correct position in the housing.

When the pinion is mounted on two bearings behind the gear, it is called an overhung mounting. Some differential pinions have a third bearing mounted in front of the pinion gear. This bearing is often called a pilot bearing. This arrangement is called a straddle-mounted pinion.

The problem in mounting the drive pinion is to keep it in proper mesh with the ring gear. When the drive pinion is driving the ring gear, two forces result. One is end thrust load and the other is radial load. Thrust load is a force acting parallel to the axis of the shaft, while radial load acts at right angles to the shaft.

Bearings installed on both sides of the pinion gear control the problem of radial loading. The tendency of the pinion gear to change its radial relationship with the ring gear is held back on both sides of the gear. In the overhung-type mounting, the tendency of the pinion gear to change this relationship with the ring gear is held back on only one side of the gear.

When the drive pinion is straddle mounted, the tapered roller bearings can be mounted close together since they do not have to hold back against the pinion gear's tendency to change relationship with the drive gear and get out of mesh. The pilot bearing resists this movement. In the overhung-mounted drive pinion, the tapered roller bearings are spread farther apart, so that the front bearing has a longer lever arm against the rear bearing (pivot) to hold the pinion gear in proper mesh.

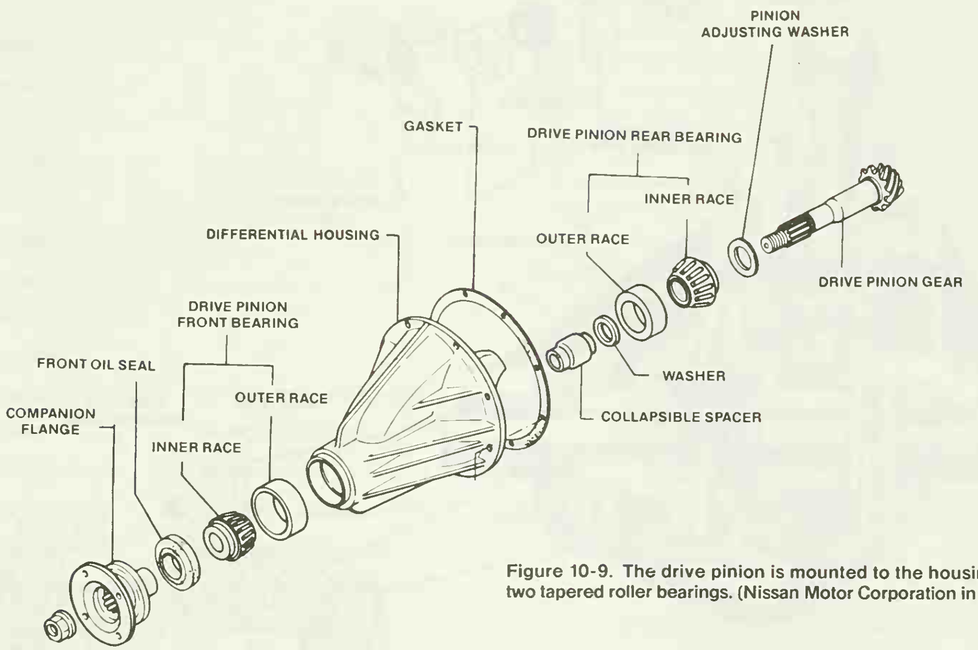


Figure 10-9. The drive pinion is mounted to the housing on two tapered roller bearings. (Nissan Motor Corporation in USA)

The ring gear and case assembly are mounted in the case on two tapered roller bearings. The ring gear is attached to the case with bolts which go through the case and thread into the ring gear. A tapered roller bearing is attached to each side of the case assembly. An outer race for each of the case bearings is mounted in the housing. One method of bearing mounting is shown in Figure 10-10. Each bearing is held in the housing with a bearing cup which is bolted to the housing. An adjusting nut which fits into threads in the cup is used to position the assembly.

An exploded view of the case assembly is shown in Figure 10-11. Most units use two pinion gears. The pinion gears are mounted on a shaft called a cross shaft or pinion shaft. They are mounted so that the gears may rotate on the shaft during differential action. A roll pin or bolt lock is used to hold the cross shaft into the case. The two side gears are splined to the axle shafts and may be held in position with retaining rings. Each pinion and side gear has a thrust washer behind it to control its position in relation to the case. A cross-sectional view of a differential assembly with an overhung pinion is shown in Figure 10-12. A differential assembly with a straddle-mounted pinion is shown in Figure 10-13.

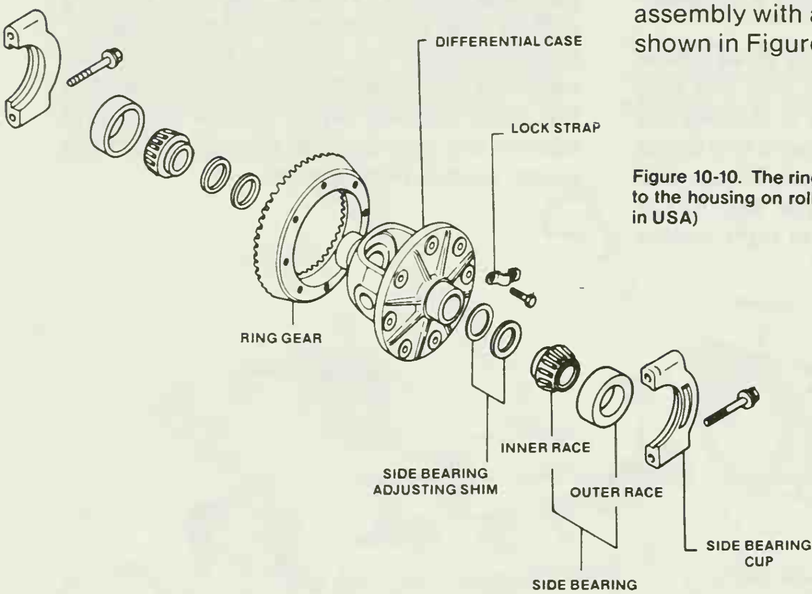


Figure 10-10. The ring gear and differential case are mounted to the housing on roller bearings. (Nissan Motor Corporation in USA)

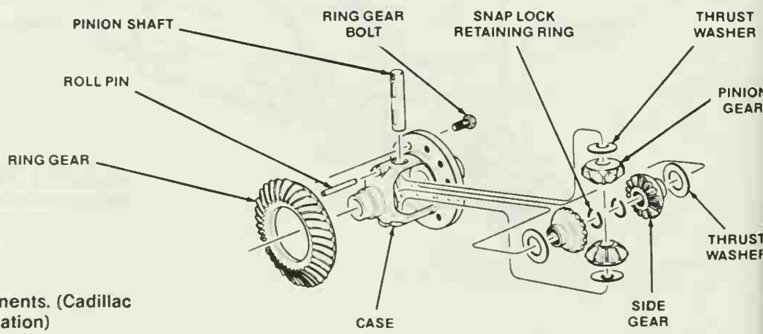
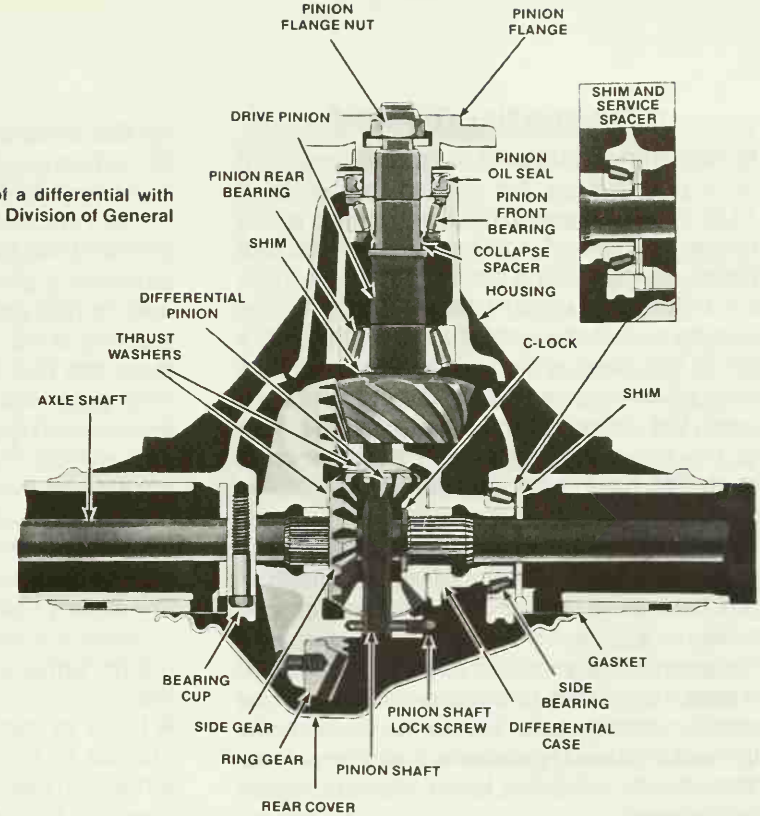
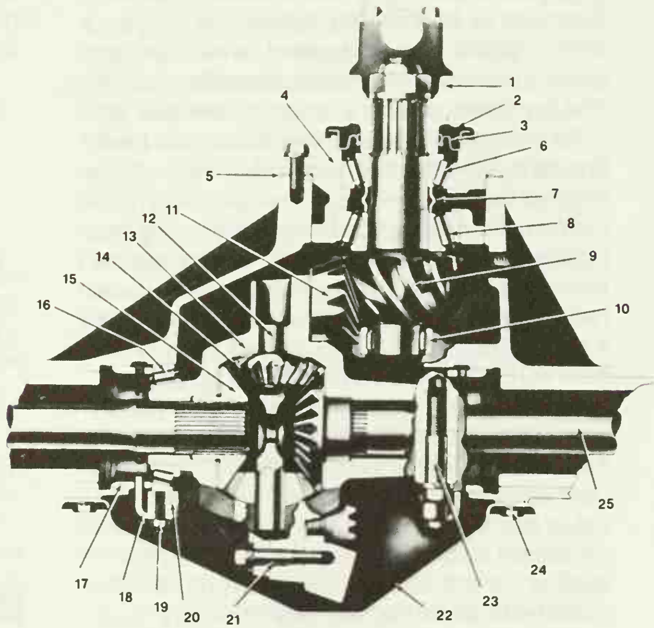


Figure 10-11. Exploded view of case components. (Cadillac Motor Car Division of General Motors Corporation)

Figure 10-12. A cross-sectional view of a differential with an overhung pinion. (Cadillac Motor Car Division of General Motors Corporation)





1. COMPANION FLANGE
2. OIL DEFLECTOR
3. OIL SEAL
4. BEARING RETAINER
5. SHIM
6. PINION FRONT BEARING
7. COLLAPSE SPACER
8. PINION REAR BEARING
9. DRIVE PINION
10. STRADDLE BEARING
11. RING GEAR
12. DIFFERENTIAL SPIDER
13. DIFFERENTIAL CASE
14. DIFFERENTIAL PINION
15. DIFFERENTIAL SIDE GEAR
16. SIDE BEARING
17. SIDE BEARING ADJUSTING NUT
18. ADJUSTING NUT RETAINER
19. RETAINER SCREW
20. BEARING CUP
21. CASE-TO-RING GEAR BOLT
22. DIFFERENTIAL COVER
23. BEARING CUP BOLT
24. COVER SCREW
25. AXLE SHAFT

Figure 10-13. A cross-sectional view of a differential with a straddle-mounted pinion. (GMC Truck and Coach Division of General Motors Corporation)

DIFFERENTIAL GEARING

Most differentials use a hypoid ring and drive pinion gear set as shown in Figure 10-14. In **hypoid gears,** the teeth are curved to follow the form of a spiral. Hypoid ring and pinion gears make it possible to use an offset pattern for installation. It is not necessary to match the center lines of the gears as is the case with spiral bevel gears or straight bevel gears. When hypoid gears are used, the pinion is set below the center line of the ring gear. Vehicles that use a drive shaft can have them installed lower making it possible to lower the tunnel of the car, which in turn lowers the entire vehicle.

To compensate for the off-center mesh of the two gears and to maintain the proper amount of tooth contact, the spiral shape of the gear is designed like a hyperbolic curve. A hyperbolic curve is the shape of a curve that results when a cone (Figure 10-15) is sliced through its axis. Hypoid gears get their name from the fact that the teeth follow a hyperbolic curve.

With hypoid gears there is an endwise sliding action between the pinion teeth and ring gear teeth along with the rolling action. Because of this sliding action, the ring and pinion gears can be lapped, which in turn gives a more perfect match, smoother action, and a quieter running ring and pinion gear set.

As mentioned earlier, one important function of the differential assembly is to multiply engine torque. Torque is multiplied by providing a gear reduction between the ring and pinion. Just as we described earlier for the transmission, this torque multiplication, gear reduction is described as a gear ratio. With a differential the ratio is called differential gear ratio, or more commonly axle ratio.

The axle ratio is really a **ring and pinion gear ratio** determined by the number of teeth on the ring gear and drive pinion. The ring gear always has many more teeth than the drive pinion, which allows a further gear reduction torque increase before the power gets to the driving wheels. Most automobile manufacturers offer the buyer several rear axle ratios to suit their needs, specified as a number—3.36 to 1, for example. This means that the number of teeth on the ring gear and on the drive pinion cause the drive wheels to turn once for every 3.36 revolutions of the drive pinion.

The ratio may be calculated by counting the teeth on the ring and pinion gear. If, for example a given pinion gear has 12 teeth and its ring gear has 42, the ratio between the two is 42/12 = 3.5:1. The more revolutions the pinion makes for one turn of the ring gear, the less resistance offered to increases in engine rpm. A vehicle equipped with a 4.56:1 ring and pinion gear set will accelerate more quickly than a similar car fitted with a ratio of 2.9:1. But for purposes of fuel economy, a ratio in the 2.9:1 range is best, because engine rpm and fuel used are closely related.

Since it is not convenient to disassemble a differential and count teeth to determine the ratio, manufacturers use a code system. A letter or number code is stamped on the outside of the differential. The number or letter corresponds to a ratio. The decoding chart for the ratio is found in the manufacturer's service manual. For example, using the chart in Figure 10-16 a letter D on the differential indicates a 3.91:1 ratio. The 11/43 means there are 11 teeth on the pinion and 43 on the ring.

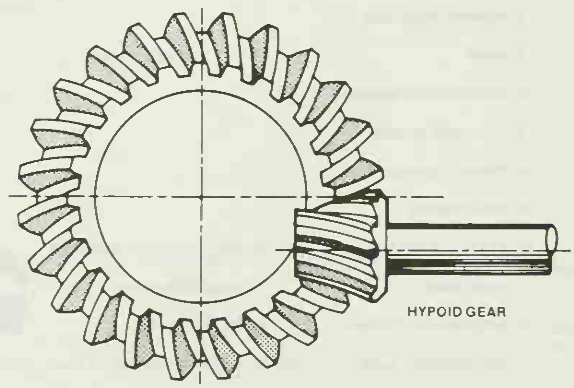


Figure 10-14. In a hypoid gear set, the pinion meshes below the ring center line.(Nissan Motor Corporation in USA)

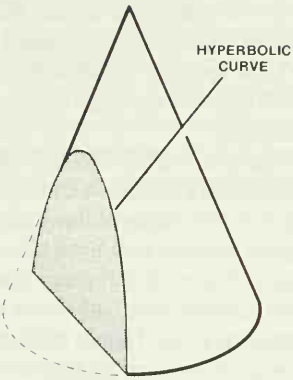


Figure 10-15. Hypoid gears follow the shape of a hyperbolic curve.

Letter	Ratio
A	3.54:1(11/39)
B	3.15:1(13/41)
C	2.87:1(15/43)
D	3.91:1(11/43)
E	3.58:1(12/43)
F	3.08:1(13/40)
G	3.31:1(13/43)
H	2.73:1(15/41)
K	2.53:1(17/43)

Figure 10-16. The decoding chart is used to find a ring and pinion ratio. (American Motors Corporation)

Pinion and ring gear sets may be classified as **hunting,** nonhunting, and partial nonhunting. Each classification has its own requirements for a satisfactory **gear tooth contact pattern.** A hunting gear set is one in which any one pinion gear tooth comes into contact with all the ring gear teeth. A nonhunting gear set is one in which any one pinion tooth comes into contact with only part of the ring gear teeth, but more than one revolution of the ring gear is required to bring out all possible gear tooth contact combinations. As an example of each, assume that in each case the pinion gear has 13, 10, 9 teeth, in that order and the matching ring gears have 39, 35, and 37 teeth in the same order.

In the first set, the ratio of the ring gear teeth to the pinion gear teeth is 39 to 13 (39/13) or 3.00:1. In one turn of the ring gear, the pinion gear turns three times. Or, three turns of the pinion turns the ring gear one revolution. Any given tooth of the pinion will come back to the same tooth space on the ring gear each time around. This is a nonhunting gear set.

In the second gear set, the ratio of the ring gear teeth to the pinion gear teeth is 35 to 10 (35/10) or 3.5:1. In this instance, any given tooth of the pinion will meet seven different teeth of the ring gear before it comes back to the starting point. It takes 3½ turns of the pinion to complete one turn of the ring gear. This is a partial nonhunting gear set.

The third gear set has 37 teeth in the ring gear and 9 teeth in the pinion gear. This gives a ratio of 37 to 9 (37/9) or 3.89:1. This is a hunting gear set. Any given tooth in the pinion gear meets each of the teeth in the ring gear before it meets the first tooth again. Nonhunting and partial nonhunting gear sets are marked so that the teeth can be properly assembled when installed in the axle. Timing marks are painted on the gear teeth for proper installation. When properly installed, the gear teeth which have been lapped together will be working together.

LIMITED-SLIP DIFFERENTIAL

The standard differential works very well for cornering. It has, however, some disadvantages when the automobile's wheels are on a slippery surface. When the automobile is driven in snow, ice, sand, or water the rear wheels may slip or lose traction. The rear axle is designed to provide all the power to the axle with the least resistance. If, for example, the left wheel should start to slip on ice, there would be less resistance on the left axle. The carrier pinions would walk around the

right axle gear, because it would have more resistance. All the power would be delivered to the left wheel, making it spin on the slippery surface. The right wheel would not turn, and the automobile would remain stationary.

This problem is eliminated in some rear axles by the addition of a set of clutch discs or cones mounted in the carrier. When the wheels encounter a slippery surface and one wheel tries to run wild, the clutch system is locked up. The power is delivered to the wheel with the best traction, not the worst. This system still allows a difference in speed of the wheels for cornering. A differential assembly with a clutch system is called **positraction,** nonslip, or **limited-slip differential.**

Limited-slip differentials fall into two categories: those with clutch plates, and those with clutch cones. Both of these units do the same job. The differential cases are similar to non-limited-slip cases except for a large internal recess in the area of each side gear. This recess provides space for either a clutch pack or a clutch cone, depending on the design.

The multiple disc clutch limited-slip differential case assembly is shown in Figure 10-17. There are two clutch assemblies called clutch packs. A clutch pack is installed behind each axle side gear. Each clutch pack consists of several steel plates, set between the case and the side gear ring. These plates and the center plate are locked to the differential case by external lugs. There are alternate plates faced with friction material that have internal spline teeth which lock to the splined hub on the side gear ring. The side gear is, in turn, splined to the axle shaft. A set of springs called preload springs provides a separating force on the two side gears.

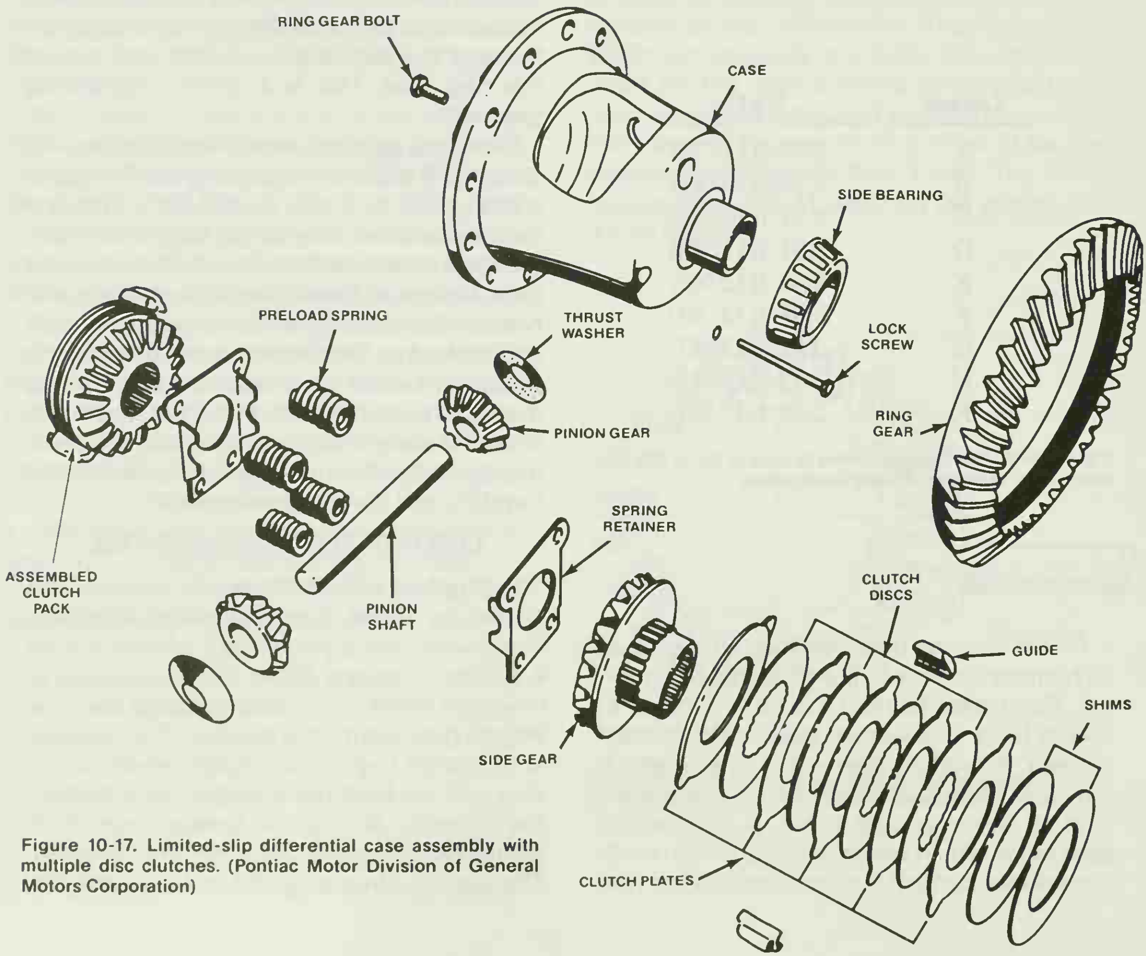


Figure 10-17. Limited-slip differential case assembly with multiple disc clutches. (Pontiac Motor Division of General Motors Corporation)

A limited-slip differential provides a driving force to the wheel with traction before the other wheel begins to spin. Figure 10-18 shows a limited-slip differential where the left wheel is on a slippery surface and the right wheel has good traction. The separating force between pinion gears and side gears and the force of the preload springs cause the side gears to be forced outwards. This outward force squeezes the differential clutch plates between the outer face of the side gear and the inner wall of the case, as shown in Figure 10-19. This application of pressure is called "energizing" the clutch packs.

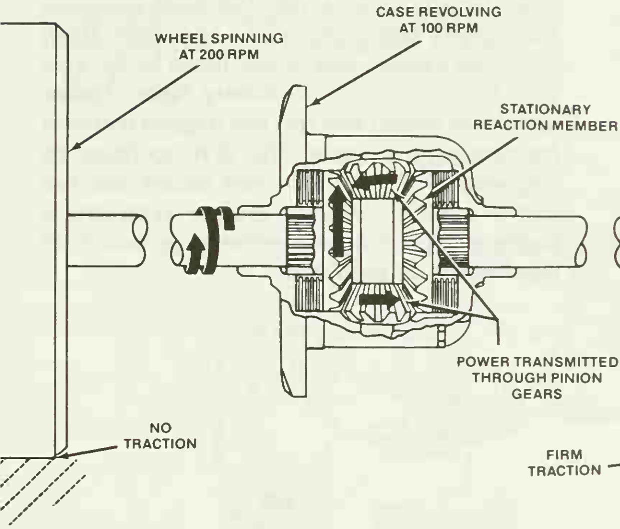


Figure 10-18. Differential in a condition of maximum slip. (Chevrolet Motor Division of General Motors Corporation)

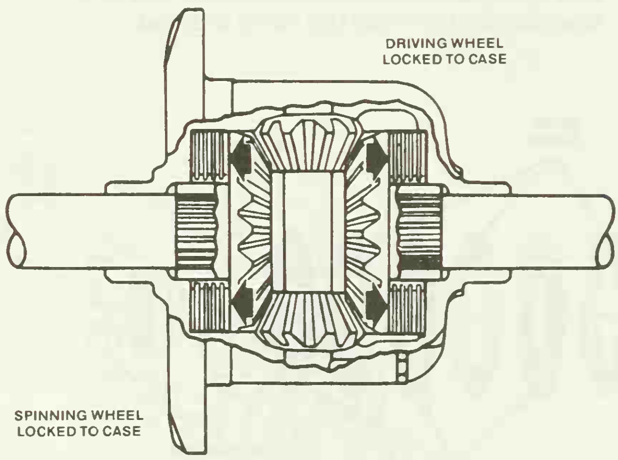


Figure 10-19. The side force applies the clutch pack. (Chevrolet Motor Division of General Motors Corporation)

The energizing of the clutch packs causes the discs to slow down to the same speed as the case, or, in effect, hold the left side gear to the case. Three things result from this condition. First, the increased resistance on the side gears causes the drive torque to apply more force on the clutch packs. Second, when the side gear is forced to turn at the same speed as the case, rapid one-wheel spin cannot occur. Third, and most important, if the case and left side gear are turning at the same speed, the right side gear (wheel with traction) is also forced to revolve in the same direction and at the same speed as the differential case. Driving force is applied to the wheel with traction causing it to rotate.

Different models of limited-slip differentials use different numbers of steel and friction discs. The clutch pack shown in Figure 10-20 has three steel and three friction discs. This unit does not have coil preload springs. Instead a convex washer called a **Belleville spring** provides a force against the plates and side gear.

The parts of a **cone clutch** limited-slip differential are shown in Figure 10-21. Each of the axle side gears is attached to a spiral cone unit called the cone clutch. The cone clutch fits into a mating cone surface in the differential case. A spring block and set of coil springs push the cone clutch units into the case and provide the initial preload.

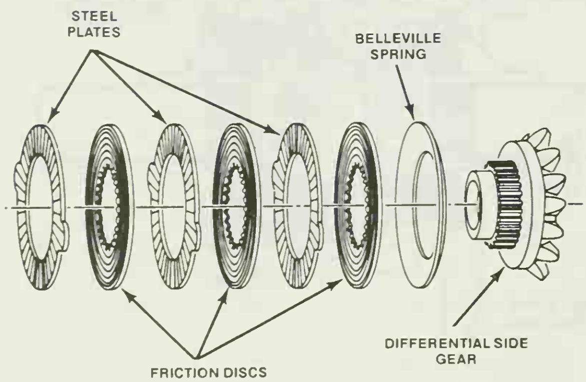


Figure 10-20. A clutch pack with a Belleville spring. (American Motors Corporation)

The action of the cone clutch design is similar to the multiple disc unit. During turns the cone clutch unit operates just like a standard differential. When a slippery surface is encountered, one of the wheels may start to speed up as it loses traction. This action causes a speedup of that wheel's axle and axle side gear. This causes side gears to move away from each other. As the side gears move outward, the cone clutch is forced into the cone surface in the case. The two coned surfaces lock up. The case and axle side gears become locked together. Both axles are locked, and power flows to the axle with the best traction. **Safety Note:** ***Never raise one wheel and run the engine with the transmission in gear. The driving force to the wheel on the floor will cause the car to move. Do not use "on the car" type wheel balancers on the rear wheels, unless both wheels are off the floor.***

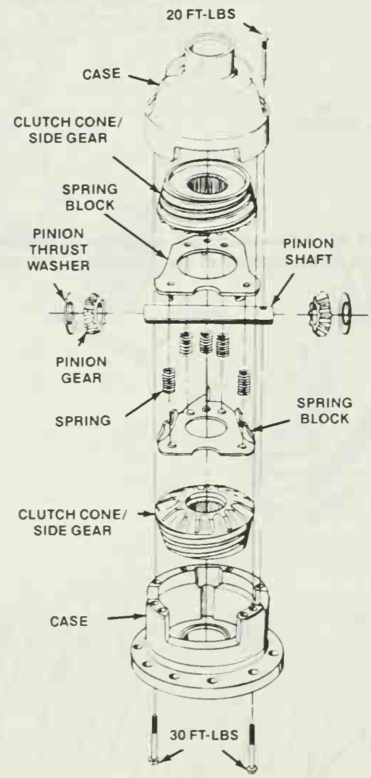


Figure 10-21. Parts of a cone-clutch limited-slip differential assembly. (Pontiac Motor Division of General Motors Corporation)

DIFFERENTIAL TYPES

All standard and limited-slip differentials work the same. There are, however, some differences in differential mounting and parts arrangement. In this section we will present some of the different styles of differentials.

When the vehicle has a front engine and front-wheel drive or a rear engine and rear-wheel drive, the differential and transmission may be combined into one unit. This assembly is called a transaxle. The word transaxle is a combination of trans (transmission) and axle (drive axle). A typical transaxle is shown in Figure 10-22. The parts and operation are like a standard differential. We will present transaxles in more detail in a later unit.

Some front-wheel drive vehicles and many four-wheel vehicles have a differential assembly mounted in a separate housing. A front-drive axle assembly is shown in Figure 10-23. The long tubular unit on either side of the differential assembly houses the drive axles. We will present the operation and service of the drive axles in later units. Since this front-drive axle supports the front wheels, steering linkage and front-wheel brakes are part of the assembly.

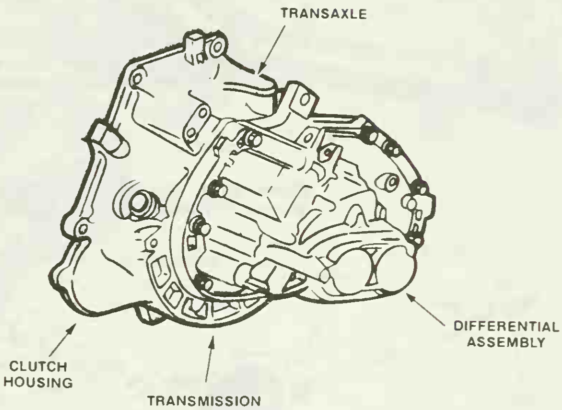


Figure 10-22. The clutch housing, transmission, and differential are combined in one unit with a transaxle. (Chevrolet Motor Division of General Motors Corporation)

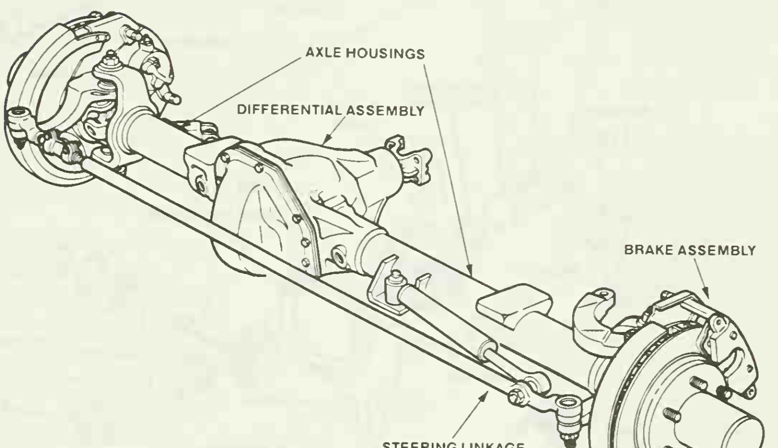


Figure 10-23. A front-drive differential and axle assembly. (GMC Truck and Coach Division of General Motors Corporation)

When a vehicle has a front engine and rear-wheel drive, a separate differential housing is used at the rear of the vehicle (Figure 10-24). This unit has a drive shaft to deliver power from the transmission. We have presented the operation and service of drive shaft assemblies in an earlier unit. The rear-mounted differential provides housings for the drive axles. The housing is mounted through springs and control linkages to provide the rear suspension.

There are two basic types of differentials mounted in separate housings. One type is described as the **integral** or **unitized differential.** The carrier assembly for the ring and pinion is not removable from the axle housings. A removable rear cover allows access to the ring gear and case assembly. An exploded view of the integral differential assembly is shown in Figure 10-25.

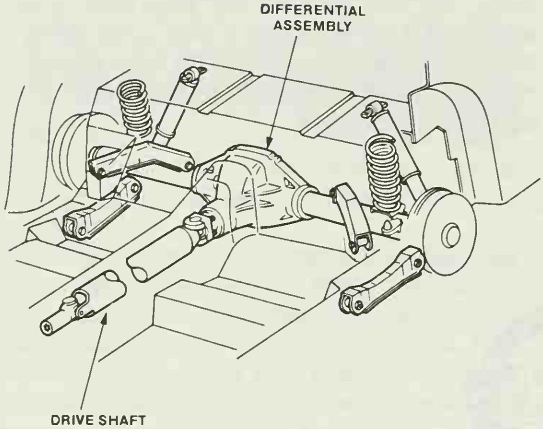
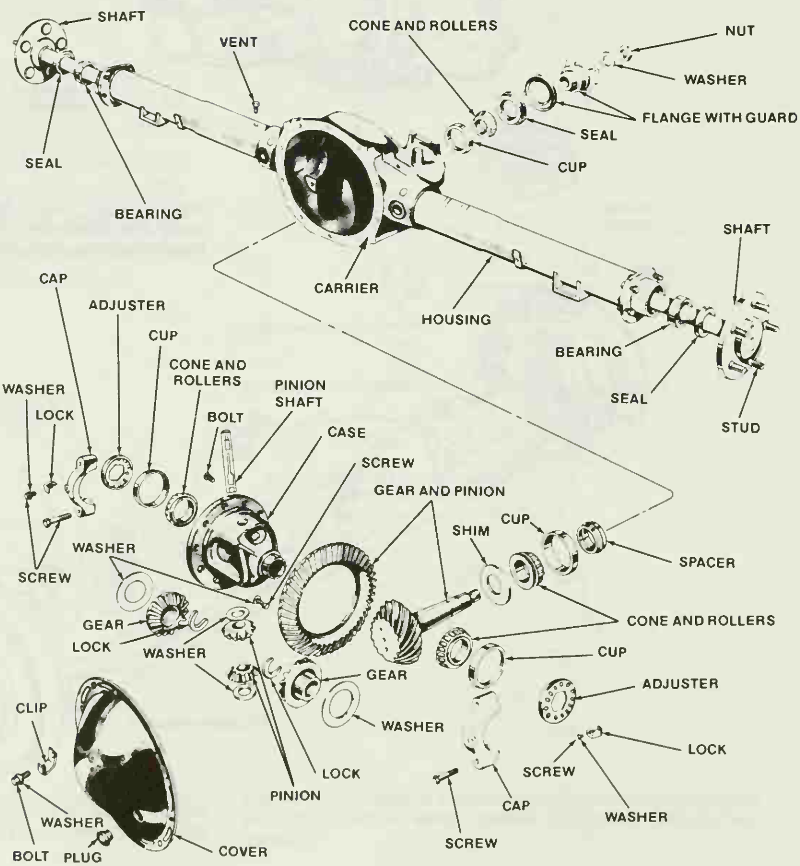


Figure 10-24. A separate differential and rear axle housing used with a front-engine, rear-drive vehicle. (Chevrolet Motor Division of General Motors Corporation)

Figure 10-25. The differential carrier is not removable on an integral or unitized differential assembly. (Chrysler Corporation)



The other type of differential assembly is called a **removable carrier** type. As shown in Figure 10-26 the entire carrier assembly may be unbolted and separated from the axle housings. These two types of differential assemblies are serviced differently as we will see in the unit on differential service.

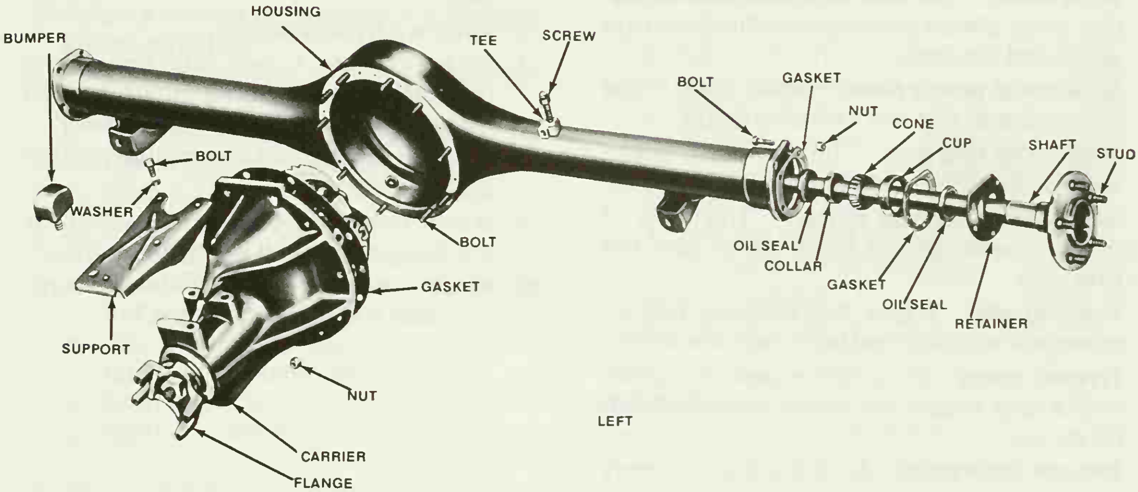


Figure 10-26. A removable carrier can be separated from the axle housing. (Chrysler Corporation)

NEW TERMS

Axle side gears Gears in the differential case used to drive the axle.

Belleville spring A round disc that flexes when pushed in the middle.

Carrier Housing in which the drive pinion and case assembly are mounted.

Case Differential component used to mount the ring gear, axle side gears, and differential pinions.

Cone clutch A limited-slip differential clutch that uses coned surfaces on the axle side gears and the case.

Differential pinion gears Small gears in the case in mesh with the axle side gears.

Differential ring gear The gear in the differential that meshes with the drive pinion gear.

Gear tooth contact pattern The area of contact between the drive pinion and the ring gear.

Hunting gear A gear that meshes with another gear with different teeth each revolution.

Hypoid gears Drive pinion and ring gears with a gear shape that allows them to mesh off center.

Integral differential A differential assembly in which the case assembly is not removable from the carrier.

Limited-slip differential A differential assembly with cones or multiple clutch discs splined to the axle side gears and the case.

Positraction A differential assembly which uses clutches in the carrier for improved traction.

Removable carrier A type of differential assembly in which the carrier may be removed from the axle housings.

Ring and pinion gear ratio The ratio between the ring gear and the drive pinion in the differential.

Side gears Same as axle side gears.

Unitized carrier A carrier assembly that is not removable from the axle housing. Also called an integral carrier.

Unitized differential Same as integral differential.

CHECK YOURSELF

1. Why must the driving wheels turn at different speeds when cornering?
2. What is the power flow through the differential when the vehicle is traveling straight ahead?
3. What is the power flow through the differential when the vehicle is in a turn?
4. What four gears are inside the case?
5. What gear meshes with the drive pinion gear?
6. What is a hypoid gear?
7. With a 3.36 to 1 gear ratio how many times does the drive pinion go around for each revolution of the rear wheel?
8. What are the limited-slip multiple clutch discs splined to?
9. When does the limited-slip cone or multiple-disc clutch energize?
10. What is the difference between a removable and unitized carrier?

CERTIFICATION PRACTICE

1. A vehicle is turning a corner. Mechanic A says the inside wheel must turn more slowly than the outside wheel.
   Mechanic B says the outside wheel must turn more slowly than the inside wheel.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. When a vehicle is traveling in a straight ahead direction:
   a. The differential pinions rotate on the pinion shaft
   b. The differential pinions do not rotate on the pinion shaft
   c. Both a and b
   d. Neither a nor b
3. When a vehicle is cornering:
   a. The differential pinions rotate on the pinion shaft
   b. The differential pinions do not rotate on the pinion shaft
   c. Both a and b
   d. Neither a nor b

5. The drive pinion gear is meshed with:
   a. Pinion shaft
   b. Axle side gears
   c. Ring gear
   d. Differential pinions
6. The differential pinion gears are meshed with:
   a. Drive pinion
   b. Ring gear
   c. Pinion shaft
   d. Axle side gears

   a. Drive pinion
   b. Ring gear
   c. Cross shaft
   d. Axle side gears
7. A drive pinion gear with a pilot bearing is:
   a. Overhung mounted
   b. Straddle mounted
   c. Both a and b
   d. Neither a nor b
8. A 3.5 to 1 ring and pinion ratio is exchanged for a 2.9 to 1 ratio.
   Mechanic A says acceleration may be slower.
   Mechanic B says fuel mileage may be increased.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
9. In a limited-slip differential the side gears are connected to the case by:
   a. Cone clutch
   b. Multiple-disc clutch
   c. Either a or b
   d. Neither a nor b
10. The axle housing and carrier assembly are one unit in the:
    a. Integral carrier design
    b. Unitized carrier design
    c. Both a and b
    d. Neither a nor b

ANSWERS:

1.a, 2.b, 3.a, 4.c, 5.c, 6.d, 7.b, 8.c, 9.c, 10.c

DISCUSSION TOPICS AND ACTIVITIES

1. Using a shop differential observe the power flow when both axles are free to turn. What is the difference in the power flow when one axle is held?
2. Count the teeth on a shop ring and pinion gear. What is the gear ratio?

Unit 11
Differential Assembly Service

The bearings and gears inside the differential are subject to alternate loading and unloading as the vehicle is accelerated or decelerated. This loading and unloading eventually leads to wear on differential parts. Wear may become noticeable as a whining noise or clunk when the vehicle changes speed. In this unit we will explain the preventive maintenance necessary on a differental, describe the troubleshooting procedures used to diagnosis a differential problem, and explain the service procedures necessary to overhaul a differential.

Preventive Maintenance

Troubleshooting

Service

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

11-1 Drain, refill, and check differential lubricant level.
11-2 Perform a differential road test and noise diagnosis.
11-3 Replace a pinion seal.
11-4 Remove a carrier assembly.
11-5 Disassemble a carrier assembly.
11-6 Clean and inspect differential components.

11-7 Check pinion depth.
11-8 Install pinion and measure pinion preload.
11-9 Reassemble the case.
11-10 Adjust differential bearing end play and check runout.
11-11 Install case and adjust backlash.
11-12 Check ring and pinion gear tooth contact pattern and replace assembly.
11-13 Service a cone clutch limited-slip differential case.
11-14 Service a multiple-disc limited-slip differential case.

JOB COMPETENCY 11-1 DRAIN, REFILL, AND CHECK DIFFERENTIAL LUBRICANT LEVEL

The differential gears and bearings are lubricated by a gear lubricant in the differential housing. The lubricant is splashed on the parts by the rotating gears. The lubricant level must be high enough in the housing so that enough of the lubricant will be splashed on the parts. You must change the lubricant at times because metal from the wearing gears and bearings gets into the lubricant.

The differential housing has a fill plug, usually in the rear as shown in Figure 11-1. This plug is removed to inspect or refill the lubricant level. To check for the correct level, raise the vehicle on a hoist, making sure it is level. Remove the fill plug. Place a finger in the hole and feel for the lubricant level as shown in Figure 11-2. The lubricant should be at the level of the fill plug hole. If the level is low, add the correct type of lubricant. **Safety Note:** ***Make sure the drive wheels are not rotated when checking the level or your finger could be pinched by a differential gear.***

Always check the manufacturer's service manual for the correct type of lubricant to use. There are many types and viscosities

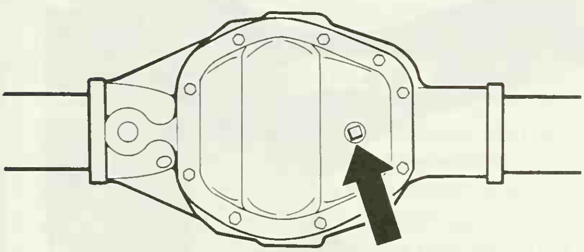


Figure 11-1. Fill plug in rear of differential housing is removed to check or fill with lubricant. (American Motors Corporation)

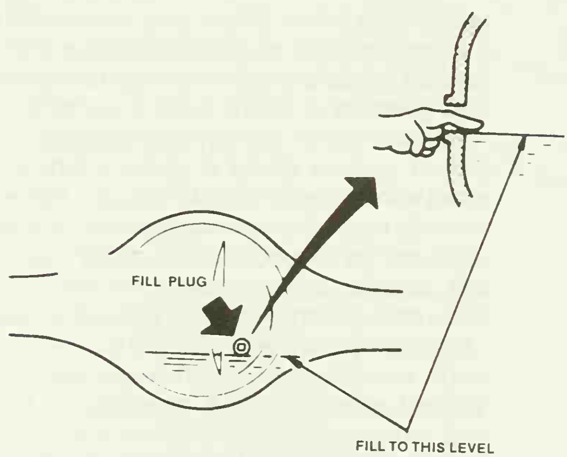


Figure 11-2. Differential lubricant level is checked with a finger in the fill plug hole. (Nissan Motor Corporation in USA)

of gear lubricants. Differentials with limited-slip clutch plates must have the correct type of lubricant or the plates may be damaged.

Some differentials have a drain plug for changing the old lubricant. Remove the drain plug and allow the lubricant to drain into a pan. Most differentials, however, do not have a drain plug. Unitized carriers have a rear cover. To remove this cover, first remove the bolts that attach it to the housing (Figure 11-3). Remove the cover and let the lubricant drain into a pan. Replace the cover, using a new gasket and fill the unit through the fill plug hole.

The removable carrier-type differential does not have a removable cover. When the housing does not have a drain plug, but the lubricant requires changing, a suction gun, shown in Figure 11-4 may be used to remove the contaminated lubricant through the filler hole.

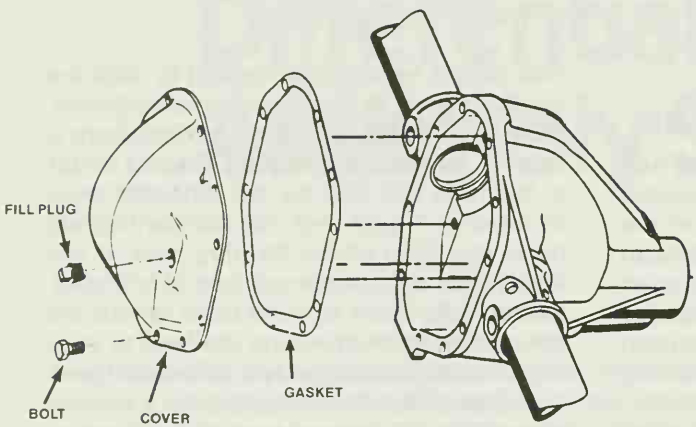


Figure 11-3. The rear cover is removed to drain the lubricant from a unitized carrier. (GMC Truck and Coach Division of General Motors Corporation)

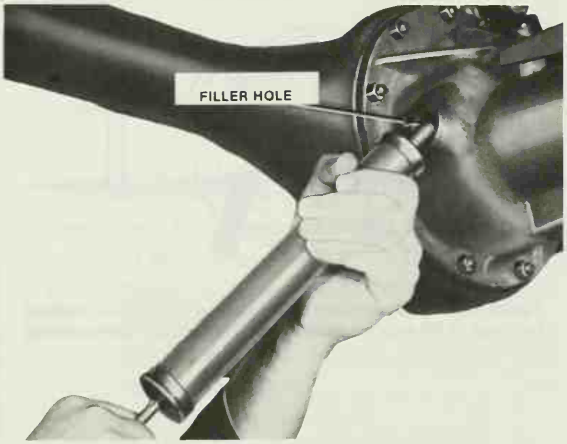


Figure 11-4. A suction gun is used to remove the lubricant through the fill plug hole on removable carrier differentials. (Chrysler Corporation)

JOB COMPETENCY 11-2 PERFORM A DIFFERENTIAL ROAD TEST AND NOISE DIAGNOSIS

Differential problems usually show up as an abnormal noise. All differential assemblies make some noise. The mechanic must road-test the vehicle to determine whether the noise is normal or if a problem actually exists. When troubleshooting a differential noise condition, first get a description of the noise and driving conditions when the noise occurred and then road-test the automobile. Noises caused by the engine, heater, transmission, tires, wheel bearings, exhaust system drive shaft, or the action of wind on the body or grille may be incorrectly diagnosed as differential noises.

Before road-testing, check tire pressure and differential lubricant level. Some types of tire tread, tread wear, or tread patterns may cause noises. Drive the automobile on different types of road surfaces and listen for a change in the noise. If the noise changes with changes in the road surface, the tires may be the cause.

With the automobile stopped and the transmission in neutral, run the engine at different speeds. If you hear the noise during this test, the noise is caused by the engine, exhaust system, clutch, transmission, or engine-driven accessory equipment.

Noise caused by worn, loose, or damaged wheel bearings may be confused with differential noise. Wheel-bearing noise is usually more noticeable when coasting at lower vehicle speeds. Applying the brakes gently will usually change wheel-bearing noise. Another test is to turn the vehicle first left then right. This side loads the bearings, causing the problem bearing to become noisy.

Drive the automobile long enough to bring the differential to operating temperature, then drive at different vehicle speeds and in all transmission gear ranges. Differential noise conditions are usually related to vehicle speed rather than engine rpm or transmission gears. Differential noises may be classified into two types: gear noise and bearing noise.

Gear noise is identified as a whine or high-pitched resonating sound that is louder at certain speeds.

Bearing noise is usually constant and the pitch directly related to the vehicle speed. Since the drive pinion turns faster than the drive gear, the drive pinion bearing noises will be higher pitched than the differential bearing noises. Drive pinion bearings are usually heard at low speeds (20 to 30 mph).

Differential case bearings are lower in pitch because they are turning at the same speed as the wheels when the automobile is driven straight ahead. Differential bearing noise will not change when the vehicle is turned left or right or when the brakes are gently applied.

Differential clunk noises must be separated from similar noises caused by a worn universal joint. A clunk noise from the differential may be due to too much clearance between the axle side gear and differential pinion or a loose-fitting differential pinion shaft in the case.

Too much ring gear and drive pinion clearance will also result in a clunk noise. Gear noise can be caused by a wrong drive gear and drive pinion adjustment. A drive line clunk noise on first transmission engagement may also be caused by loose fitting axle side gears in the differential case bores.

A knocking or clunking noise heard at low speed when coasting may be caused by a loose-fitting axle side gear in the differential case bore. When this condition is found, applying the brakes lightly will usually reduce the sound.

Differential gear noise heard only under certain conditions such as when spinning a drive wheel during on-the-car wheel balancing, or when a drive wheel is spinning due to icy conditions, is normal. When you determine that a noise is being caused by the bearings, you do not have to replace the gears unless an inspection shows signs of obvious damage. When noise is caused by the drive pinion and drive gears at low mileage, the need for bearing replacement depends upon inspection of the bearings during overhaul.

Limited-slip differential problems often result in roughness and chatter when turning. Before you remove and disassemble any limited-slip differential because of chatter, check to see if proper lubricant is used. A complete lubricant drain and refill with specified differential lubricant will sometimes correct chatter.

JOB COMPETENCY 11-3
REPLACE A PINION SEAL

Both the unitized and removable carrier assembly have a seal to keep lubricant from leaking out around the drive pinion shaft. Lubricant leakage around the pinion shaft usually indicates a pinion seal that requires replacement.

A sectional view through a typical pinion assembly is shown in Figure 11-5. The seal is held by a press fit in the housing. The lip of the seal rides on a smooth surface of the universal or companion flange. The companion flange is retained on the pinion shaft by the pinion nut. This nut is also used to preload the pinion bearings. The adjustment of the pinion bearing preload will be described later.

To install a new seal, raise the vehicle on a hoist or support it on jack stands. Remove rear wheels and brake drums. Disconnect the drive shaft from the rear yoke. Mark the pinion shaft and yoke for assembly reference. Rotate the drive pinion several revolutions. Use a companion flange nut socket tool and an inch-pound torque wrench to check torque. Record the torque required to turn the drive pinion for reference at time of assembly.

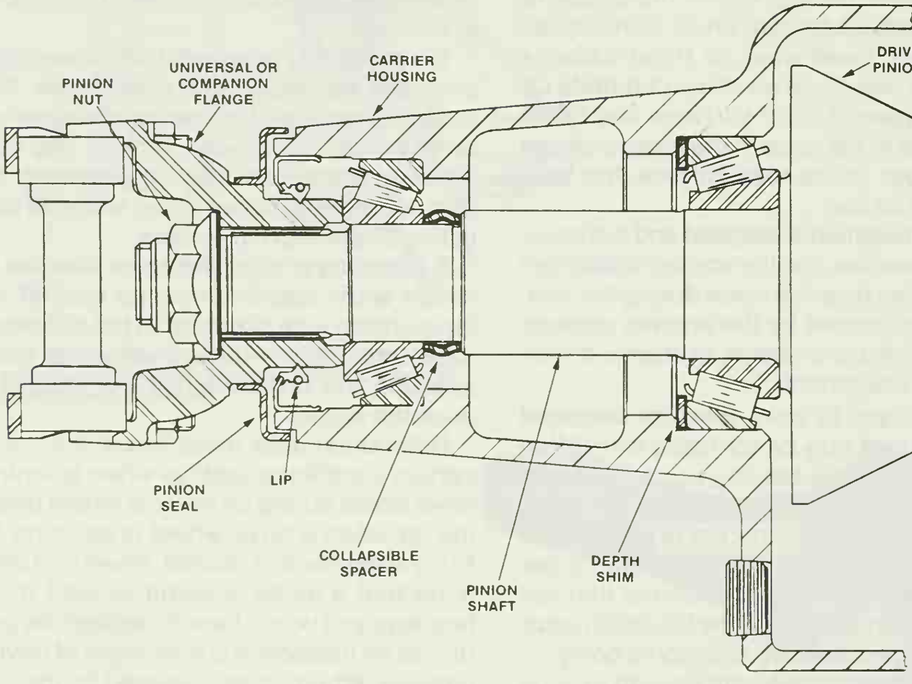


Figure 11-5. The pinion seal prevents lubricant from leaking out around the pinion shaft. (American Motors Corporation)

Remove the pinion nut. Use a companion flange holder and remover tool and a companion flange nut socket tool as shown in Figure 11-6. Discard the pinion nut; it must not be reused. Mark the flange and drive pinion shaft to assure correct alignment at the time of assembly. Remove the rear flange using a holding tool and puller as shown in Figure 11-7.

Inspect the seal surface of the flange. If the surface is damaged or grooved, replace the flange. Remove the pinion oil seal using a seal remover. Before installing the replacement seal, coat the seal lip with rear axle lubricant. Install the seal using a pinion oil seal installer.

Install the flange on the pinion shaft; note alignment marks. Install a new pinion nut. Tighten the nut to remove pinion bearing end play only. Do not overtighten. Check the torque required to turn the drive pinion. The pinion must be turned several revolutions to obtain accurate torque reading. Refer to the torque reading recorded during disassembly, and add five inch-pounds for the proper amount of torque. If preload torque is less than the desired amount (disassembly torque reading plus five inch-pounds), tighten the pinion nut slightly and check torque. Repeat these steps until the desired torque is attained. Do not loosen and retighten nut.

Do not overtighten the pinion nut. If you exceed the desired torque you must install a new collapsible pinion spacer sleeve and reset the pinion gear preload as described in a following section. Install the drive shaft. Align the index marks made at disassembly. Install rear brake drums and wheels. Road-test the vehicle.

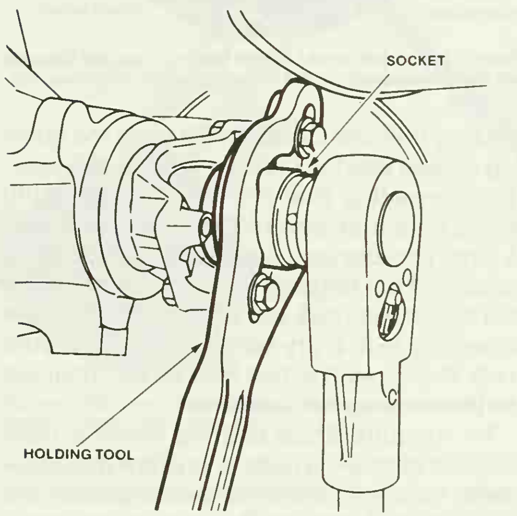


Figure 11-6. A holding tool prevents the companion flange from rotating as the pinion nut is removed. (American Motors Corporation)

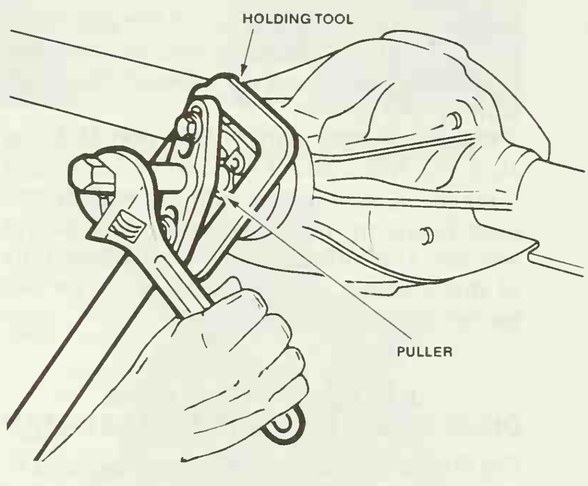


Figure 11-7. The companion flange is removed from the pinion splines with a puller. (American Motors Corporation)

JOB COMPETENCY 11-4
REMOVE A CARRIER ASSEMBLY

When diagnosis procedures indicate a problem inside the differential, the component parts are removed for service. The removable carrier and unitized carrier differentials are disassembled in different ways.

With both types, raise the rear of the car high enough to permit working under it. Lift the vehicle on a hoist or **place jack stands solidly under frame members on both sides.**

Mark the rear universal joint and pinion flange for proper reassembly. Then disconnect the rear universal joint from the flange by removing four bolts and two straps or U-bolts on the single joint connection. Remove the drive wheels and brake drums or disc brake calipers and rotors. Remove the drive axles. The procedure for axle removal is presented in a later unit. As described later, it may be necessary to remove the axle retainer inside the case. If the carrier housing had a drain plug, remove it and allow the lubricant to drain. On a unitized carrier remove the rear cover and allow the lubricant to drain.

On a removable carrier unit, remove the bolts or nuts which hold the carrier assembly to the axle housing. Place a drain pan under the axle housing to catch the lubricant. Lift the carrier assembly out of the axle housing. The carrier assembly may be mounted in a holder or placed on a bench for disassembly and service.

When a unitized carrier assembly requires service, the individual components are removed and serviced with the carrier and axle housing assembly mounted in the vehicle. The differences in the disassembly of the unitized and removable carrier will be described below.

JOB COMPETENCY 11-5
DISASSEMBLE A CARRIER ASSEMBLY

The first step in disassembling the carrier is to make a punch mark on each of the threaded differential bearing cups as shown in Figure 11-8. These cups must be installed in the same position on reassembly. Loosen the bearing cup attaching bolts until only several threads are engaged and pull the bearing cups away from the bearings. This will prevent the differential from falling out and being damaged when it is pried out of the axle housing.

On a removable carrier the case assembly may be lifted out when the bearing cups are removed. The housing on the unitized carrier provides a tension against the ends of the case. It may be possible to insert a pry bar into the case and pull the case out of the housing. Leaving the cups on loosely prevents the case from flying out.

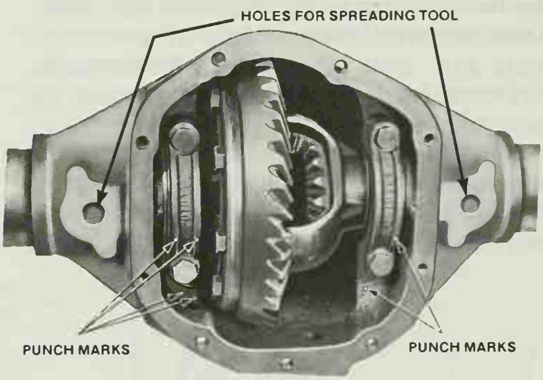


Figure 11-8. Punch marks on the bearing caps and housing will show reassembly in the correct position. (Chrysler Corporation)

Many unitized carriers must have the housing spread apart in order to remove the case. The spreading tool fits into the two blind holes on either side of the carrier housing. A large adjuster on the **spreader** tool is turned to spread the housing .010 to .015 inch. With the housing spread, you can remove the case assembly with a pry bar as shown in Figure 11-9. The spreading tool may be left mounted on the housing for reassembly.

Tie the differential bearing shims to their respective bearing cups to prevent misplacement. Remove differential bearings from the case using a puller as shown in Figure 11-10. When using this tool, be sure it pulls on the bearing cone and not the cage. If the puller bears on the bearing roller cage, the cage will be damaged.

Remove the ring-gear-to-case bolts and remove the gear from the case using a brass drift and a hammer as shown in Figure 11-11. Do not nick the drive gear mating face of the case or drop the gear. Do not attempt to chisel or wedge the gear from case. Mount the case

in a soft-jaw vise. Remove the pinion shaft lockpin using a punch that is 3 inches long by 3/16 inch (76 mm by 5 mm) in diameter as shown in Figure 11-12.

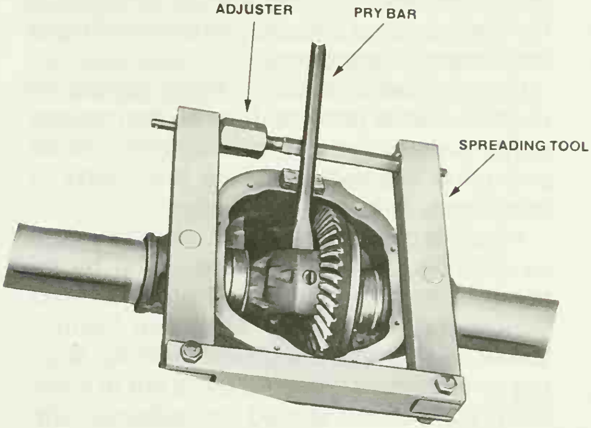


Figure 11-9. The spreading tool spreads the housing apart to allow removal of the case. (Chrysler Corporation)

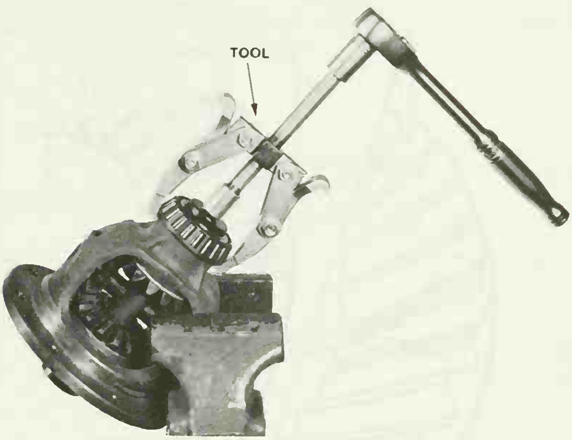


Figure 11-10. The differential case bearings are removed with a puller. (American Motors Corporation)

Measure and record the differential side-gear-to-case clearance for assembly reference. Insert equal thickness feeler gages between each gear and the case to measure clearance. Record you measurement. For accurate measurement, do not remove either feeler gage until you measure the clearance at both gears.

Remove the pinion shaft using a punch and hammer and remove the thrust block through the differential side gear bore as shown in Figure 11-13. Roll the differential pinions around on the differential side gears until the pinions and thrust washers can be removed from the case. Then remove the side gears and washer.

Figure 11-11. After the bolts are removed, the ring gear is removed by tapping it with a brass drift.

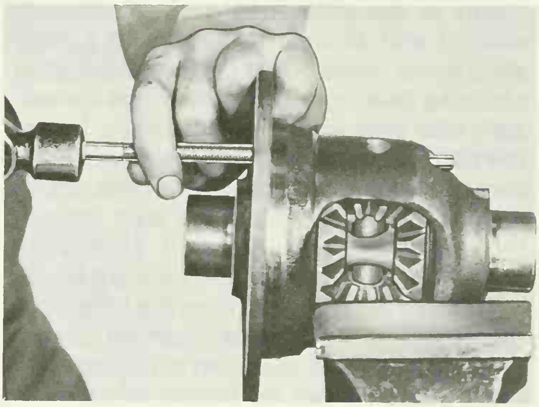


Figure 11-12. Pinion shaft lockpin or cross shaft lockpin is removed with a punch. (American Motors Corporation)

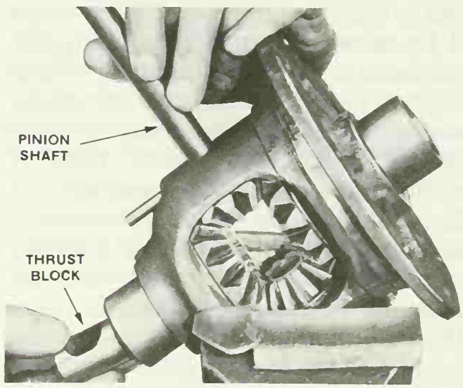


Figure 11-13. Removing the pinion shaft or cross shaft and thrust block. (American Motors Corporation)

Remove the companion flange and pinion nut using the holding tool and puller as described earlier under pinion seal removal. After removing the nut on the unitized carrier, install the housing cover. Secure with two bolts to prevent the drive pinion from dropping when it is driven out. Remove the pinion oil seal. Tap on the end of the drive pinion shaft with a plastic hammer to free the front bearing cone from the pinion shaft; remove the bearing. A collapsible spacer is used to control **pinion bearing preload.** Discard this spacer; it is not reusable. Remove the housing cover, drive pinion, and rear bearing from the housing.

JOB COMPETENCY 11-6 CLEAN AND INSPECT DIFFERENTIAL COMPONENTS

Clean all the differential parts in cleaning solvent and allowed to air-dry on a clean shop towel. Always use clean solvent when cleaning bearings. Oil the bearings immediately after cleaning to prevent rusting. Inspect the parts for defects. Clean the inside of the carrier before rebuilding it. When you replace a scored gear set, wash the axle housing thoroughly and steam clean it. This can be done effectively only if the axle shafts and shaft seals are removed from the housing.

Examine the ring gear teeth for scoring or excessive wear as shown in Figure 11-14. Worn gears cannot be rebuilt to correct a noisy condition. Gear scoring is the result of excessive shock loading or the use of an incorrect or too little lubricant. Scored gears cannot be reused. Examine the teeth and thrust surfaces of the differential gears. Wear on the hub of the differential gear can cause a "chucking" noise known as "chuckle" when the car is driven at low speeds. Wear of splines, thrust surfaces, or thrust washers can contribute to excessive drive line backlash.

Make sure that the differential bearing bores are smooth and that the threads are not damaged. Remove any nicks or burrs from the mounting surfaces of the carrier housing. Make sure that the hubs where the bearings mount are smooth. Carefully examine the differential case bearing shoulders, which may have been damaged when the bearings were removed. The bearing assemblies will fail if they do not seat firmly against the shoulders. Check the fit (free rotation) of the differential side gears in their counterbores. Be sure that the mating surfaces of the two parts of the case are smooth and free from nicks or burrs.

Check bearing cups for rings, scores, or excessive wear patterns. If inspection reveals either a defective cup or a defective cone and roller assembly, replace both parts to avoid early failure.

All other parts of the pinion assembly, such as gaskets, seals and shims, must be inspected for roughness and other defects which may contribute to pinion failure. Carefully examine the pinion teeth for scoring or excessive wear. All parts not in satisfactory condition should be replaced with new parts in rebuilding.

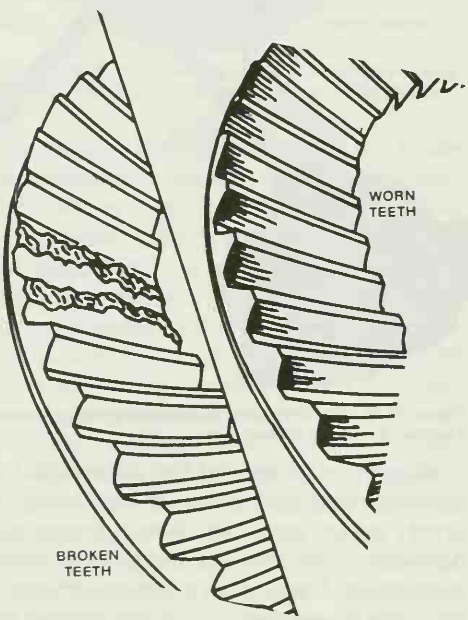


Figure 11-14. Inspect the ring gear for worn or broken teeth. (Chevrolet Motor Division of General Motors Corporation)

JOB COMPETENCY 11-7
CHECK PINION DEPTH

You must measure and adjust **pinion gear depth** before final assembly installation of the gear. This adjustment must be correct to ensure quiet, trouble-free operation.

Pinion depth is the distance (in inches or millimeters) between the pinion gear end face and axle shaft center line as shown in Figure 11-15. It is controlled by shims installed between the pinion rear bearing cup and axle housing on many unitized carrier units. On other units the shims may be located directly behind the pinion. On some removable carrier units the shims are located between the pinion housing and carrier housing.

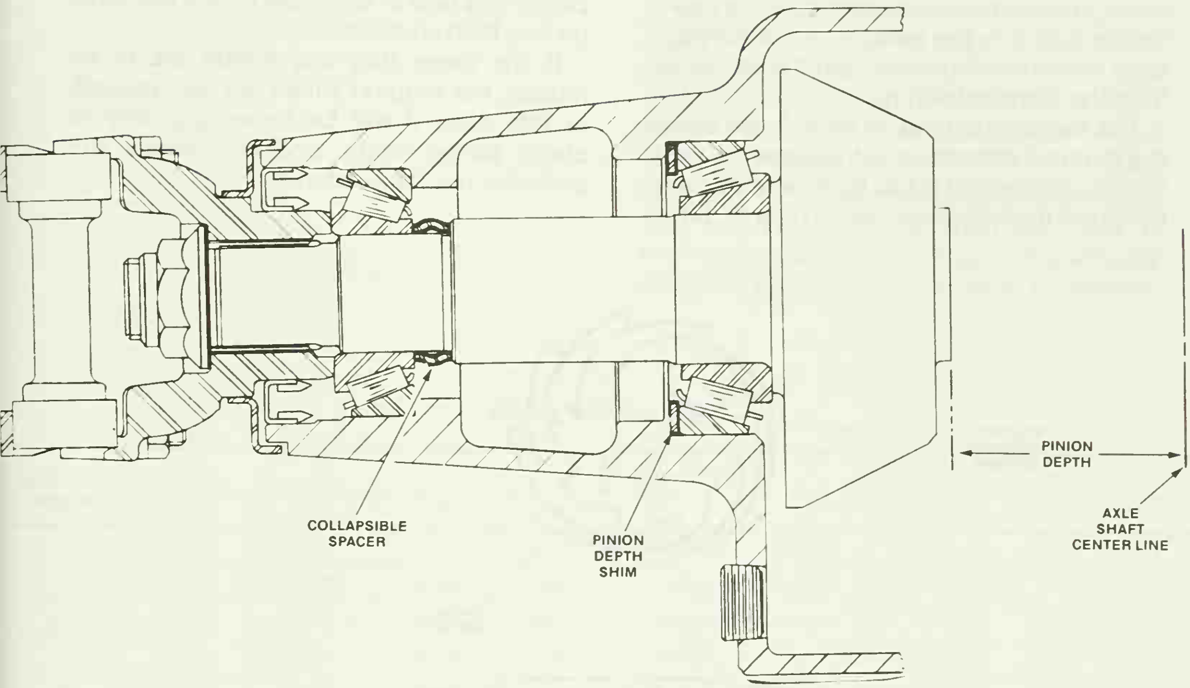


Figure 11-15. Pinion depth is the distance from the end of the pinion to the axle center line. (American Motors Corporation)

Ring and pinion sets are factory tested to detect machining variances. Tests are started at standard setting which is varied until the best tooth contact and quiet operation are obtained. When the best setting for a gear set is achieved, the gears are identified as a matched set with hand-etched numbers or paint as shown in Figure 11-16.

The ring gear receives one number. The pinion receives two numbers separated by a plus or minus sign. The second **pinion marking** number indicates pinion position in relation to the axle shaft center line, where tooth contact was best and operation most quiet. This number represents pinion depth variance and is the amount in thousandths of an inch (or millimeters) that the set varied from the standard setting.

The **standard setting,** or sometimes called the **nominal dimension** is the same for each type of differential made by a manufacturer. Different manufacturers and types of differentials have different standard settings. Pinion gears are marked plus or minus in the amount, in thousandths of an inch, the gear varied from the standard setting.

For example, if a pinion is marked +2, the gear varied from standard by +0.002 inches (0.05 mm) and will require fewer shims than a set marked zero. A plus marking means the distance from the pinion end face to the axle shaft center line must be more than standard.

If a pinion is marked −3, the set varied from standard by −0.003 inches (0.08 mm) and will require more shims than a set marked zero. A minus marking means the distance from pinion end face to axle shaft center line must be less than standard.

If the same ring and pinion are to be reused, the original shims are also reused. In this case it will be necessary only to check pinion depth, and corrections will probably not be needed.

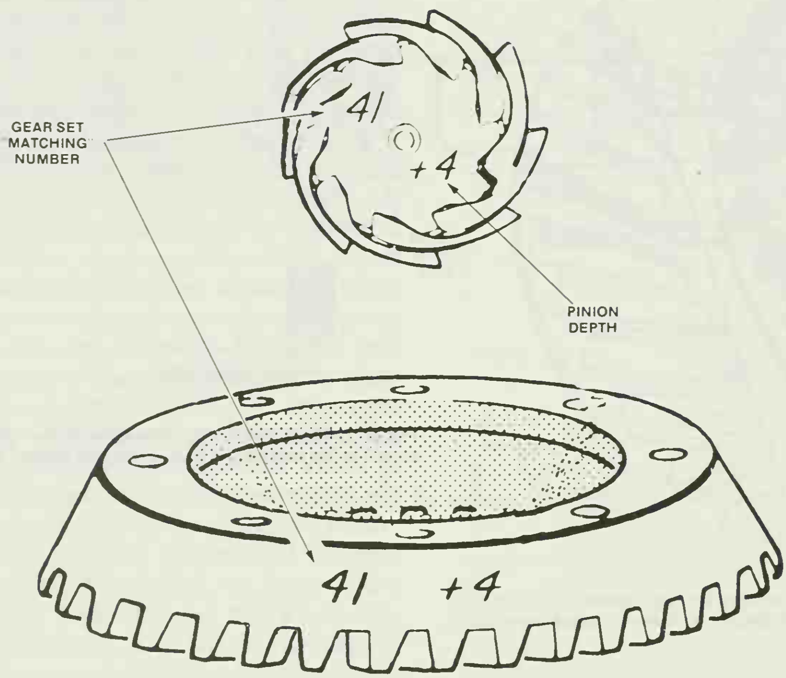


Figure 11-16. Etched markings on the ring and pinion gear indicate a matched set and give pinion depth. (American Motors Corporation)

Always replace the ring and pinion gear as a matched set. If they are to be replaced, calculate the required shim and measure pinion depth. The service manual for a differential typically provides a shim chart like the one shown in Figure 11-17. This chart will help determine the approximate starter shim thickness needed for initial pinion depth measurement. However, the chart will not provide the exact shim thickness required for final depth adjustment and must not be used as a substitute for an actual pinion depth adjustment.

To use the chart:

1. Measure thickness of original depth shim.
2. Note pinion variance numbers marked on new and old pinion gears.
3. Refer to new and old pinion marking columns in the chart. The number in the chart box where old and new depth variances intersect will provide the approximate amount of shim change needed for the starter shim thickness.

For example, if the old pinion is marked −3 and the new pinion +2, the procedure is as follows: refer to the old pinion marking column (left side of chart) and locate −3 figure in this column. Then read to right (across chart) until under the +2 figure in new pinion marking columns. The number in the box where two columns intersect is the amount of shim thickness change required. In this case, the intersecting box number is −0.005 (0.13 mm) which represents the amount to be subtracted from the old shim thickness. If the number had been a + figure, this amount would be added to the old shim thickness.

Pinion Variance Chart

Old Pinion Marking	New Pinion Marking								
	−4	−3	−2	−1	0	+1	+2	+3	+4
+4	+0.008	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0
+3	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001
+2	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002
+1	+0.005	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003
0	+0.004	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004
−1	+0.003	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005
−2	+0.002	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006
−3	+0.001	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006	−0.007
−4	0	−0.001	−0.002	−0.003	−0.004	−0.005	−0.006	−0.007	−0.008

Figure 11-17. A shim chart indicates the shim needed to start measuring the pinion depth. (American Motors Corporation)

To measure the pinion depth, measure the thickness of the original pinion depth shim. Note the depth variance numbers marked on the old and new pinion gears. Determine the starter shim thickness. Refer to the pinion variance chart and determine the amount to be added to or subtracted from the original shim thickness for the starter shim thickness.

Install the rear bearing on the pinion gear and press the bearing against the rear face of the pinion head. Clean the pinion bearing bores in the axle housing thoroughly. This is important to correct the depth measurement and adjustment. Install the starter shim in the housing bearing cup bore. Be sure the shim is centered in the bore. Install the pinion rear bearing cup, using a cup driver as shown in Figure 11-18. Install the pinion front bearing cup using the same driver. Install the pinion gear in the rear bearing cup. Install the pinion front bearing and companion flange on the pinion gear. Do not install the oil seal or spacer at this time. Install the original pinion nut on the pinion. Tighten the nut only enough to remove bearing end play. Do not install a new pinion nut and collapsible spacer now because the pinion gear must be removed after depth measurement.

Note the depth variance marked on the pinion gear. If the number is preceded by + sign, add the number to the standard setting. If the number is preceded by minus sign (−), subtract the number from the standard setting. The result of addition or subtraction is the desired pinion depth. Record this figure for assembly reference.

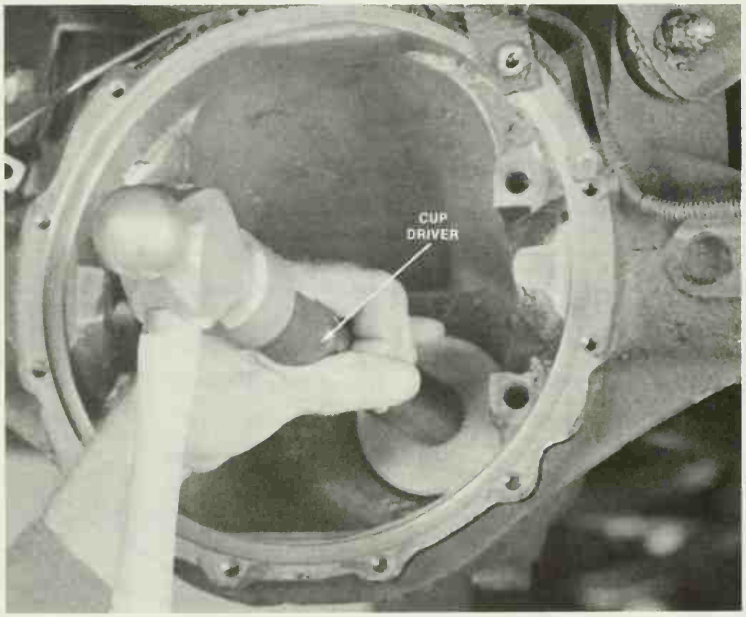


Figure 11-18. Pinion bearing cups are driven into the case with a cup driver. (American Motors Corporation)

Pinion depth is measured with a specialized dial indicating tool provided by the manufacturer. (Figure 11-19). The tool consists of an arbor that mounts in the carrier and a dial indicator that rests against the pinion. If you follow the manufacturer's installation and adjustment procedure you can read pinion depth on the face of the dial indictor. A variation of either plus (+) or minus (−) required pinion depth indicates that you must change the shim and take another depth reading.

If this depth tool is not available, you must select a shim, based on the pinion variance chart. When the differential is completely assembled check the tooth pattern to see if the pinion depth is correct. If the tooth pattern is not correct, you must disassemble the unit for a shim change. A tooth pattern check will be described in a later section.

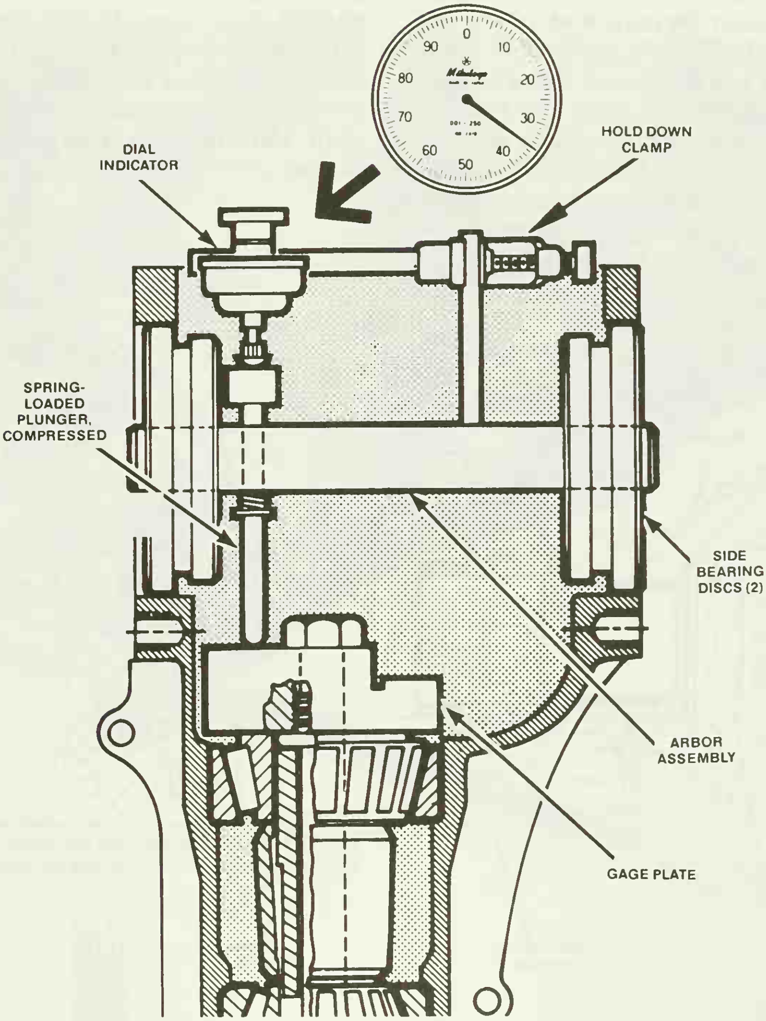


Figure 11-19. Pinion depth is measured with a dial indicator and arbor assembly. (Nissan Motor Corporation in USA)

JOB COMPETENCY 11-8
INSTALL PINION AND MEASURE PINION PRELOAD

When you determine the correct pinion depth shim, install the pinion in the carrier. The next adjustment is the pinion bearing preload. For quiet pinion and ring gear operation, the gears must be held in exactly the proper mesh. This means that the pinion gear must be held to zero end play. Zero end play, in a shaft mounted on two opposed tapered roller bearings, means that there must be zero clearance between the cone and rollers and between the rollers and cups in both bearings. If there is any clearance at the rollers, the pinion shaft will walk back and forth as the direction of thrust changes. A walking pinion shaft means that the pinion and ring gear are walking in and out of proper mesh.

To get zero end play at all times, the bearing cones are actually forced against the rollers and the rollers against their cups by tightening the pinion shaft nut. As the pinion shaft nut is tightened, the pinion shaft flange, the oil slinger, the front bearing spacer, and the rear bearing cone are forced closer together.

In most differentials the bearing spacer is collapsible as shown in Figure 11-20, so that at a specified torque on the pinion nut, the spacer is squeezed shorter. As the spacer gets shorter, the bearing cones are pulled closer together and press the bearing rollers against their cups. As the pinion shaft nut is tightened beyond the point of zero clearance at the roller bearings, the pinion shaft is stretched. This stretch remains in the pinion shaft, and it tends to keep the bearing rollers seated under all operating conditions.

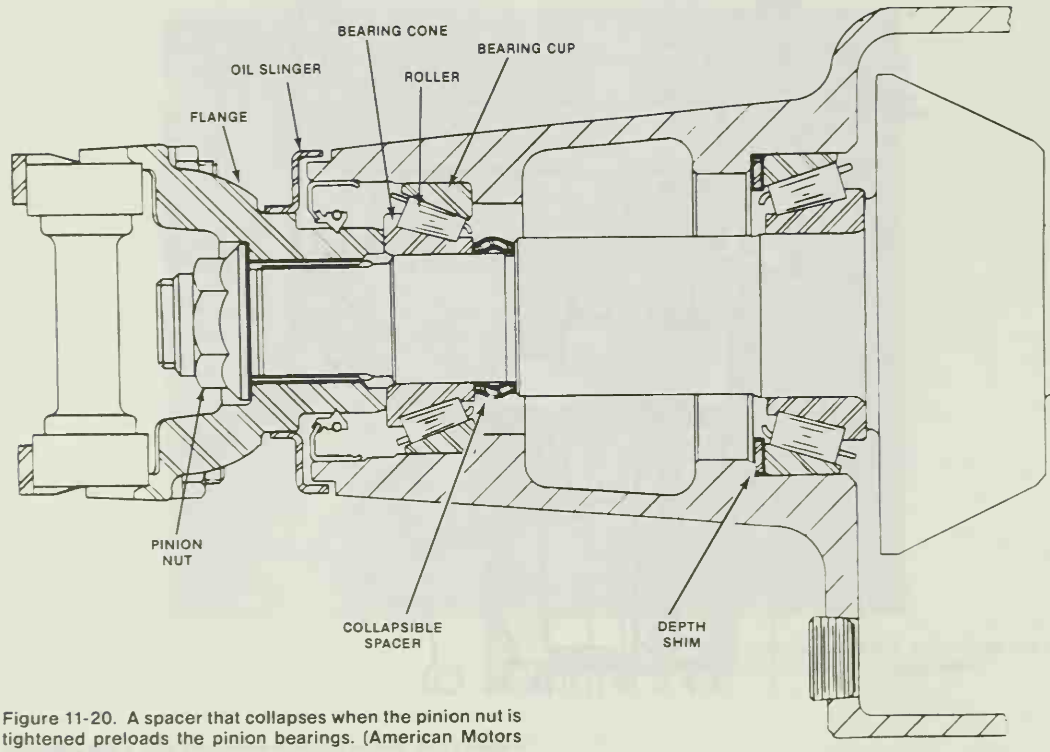


Figure 11-20. A spacer that collapses when the pinion nut is tightened preloads the pinion bearings. (American Motors Corporation)

Drive pinion preload is achieved by tightening the pinion nut. The nut is tightened to specifications with a foot-pound torque wrench. Then the preload is measured by the amount of torque in inch-pounds required to keep the pinion rotating as shown in Figure 11-21. If there is not enough preload, the torque reading will be too low. The foot-pound torque wrench may be used to tighten the nut a small amount, and the preload is checked again. If the preload setting is exceeded, the pinion must be disassembled and a new collapsible spacer installed. The preload check is then repeated. Never reuse a pinion nut after it has been backed off.

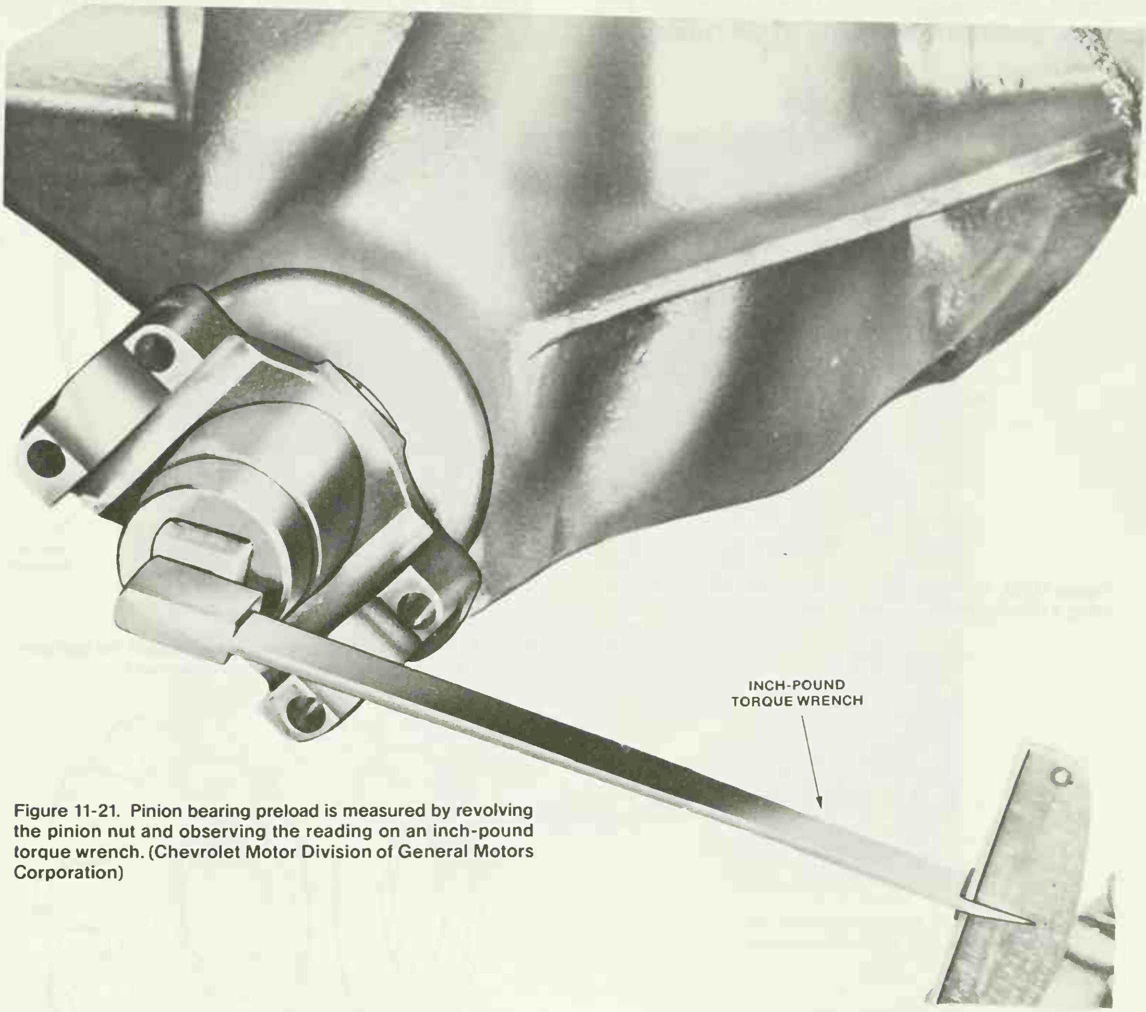


Figure 11-21. Pinion bearing preload is measured by revolving the pinion nut and observing the reading on an inch-pound torque wrench. (Chevrolet Motor Division of General Motors Corporation)

JOB COMPETENCY 11-9 REASSEMBLE THE CASE

The case reassembly begins by installing the case bearings. Use a bearing driver as shown in Figure 11-22. Always drive the bearing by the inside race.

Install the thrust washers on the side gears as shown in Figure 11-23. If the previously measured side gear clearance exceeded specifications, install replacement thrust washers. Install the assembled side gears and washers in the case. Install the replacement thrust washers on the differential pinions, as shown in Figure 11-24. Install the assembled differential pinions and the thrust washers. Mesh the pinions with the side gears so the shaft bores in the pinions are aligned. Recheck the side-gear-to-case clearance. If the clearance still exceeds specifications and replacement thrust washers have been installed, replace both side gears.

Rotate the side gears until the shaft bores in the pinions are aligned with shaft bores in the case. Install the thrust block. Align the bore in the block with the pinion shaft bores in the case. Install a differential pinion shaft. Install the locking device for the pinion shaft.

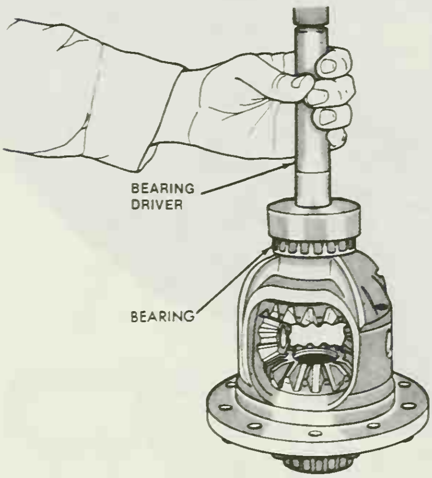


Figure 11-22. Bearings are installed on both sides of the case using a bearing driver or press. (Chrysler Corporation)

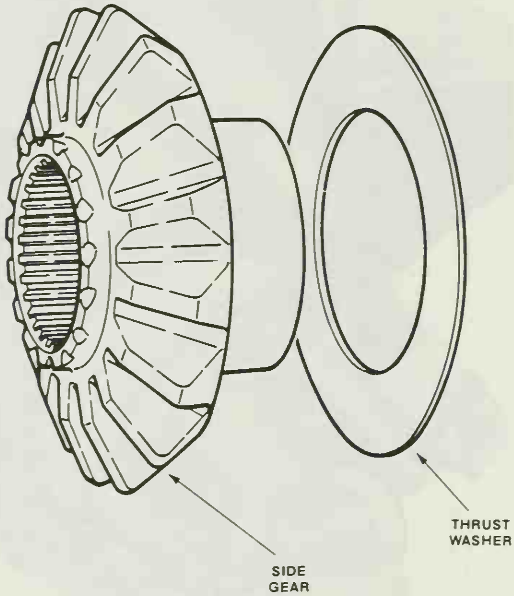


Figure 11-23. If clearance is excessive, replace the side gear thrust washers. (American Motors Corporation)

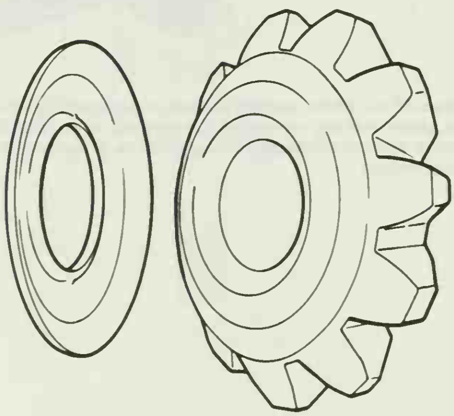


Figure 11-24. New thrust washers are installed on the differential gears. (American Motors Corporation)

JOB COMPETENCY 11-10 ADJUST DIFFERENTIAL BEARING END PLAY AND CHECK RUNOUT

Many unitized differential carriers require that the **end play** of the case bearings be adjusted by shims. These shims fit between the case bearings and the carrier housing. Place the bearing cup over each differential bearing and install the differential assembly in the axle housing. Install a shim on each side of the differential between the bearing cup and housing. Use the old shims as a starting point.

Install the bearing cups and finger-tighten the bolts. Mount the dial indicator so the indicator stylus contacts the ring gear mounting face of the case as shown in Figure 11-25. Using two screwdrivers, pry between shims and housing. Pry the assembly to one side and zero the dial indicator. Pry the assembly to the opposite side and read the dial indicator. Do not attempt to zero or read the indicator while prying. Amount read on the dial indicator is the shim thickness that must be added to arrive at zero preload and zero end play. Repeat the procedure for accuracy.

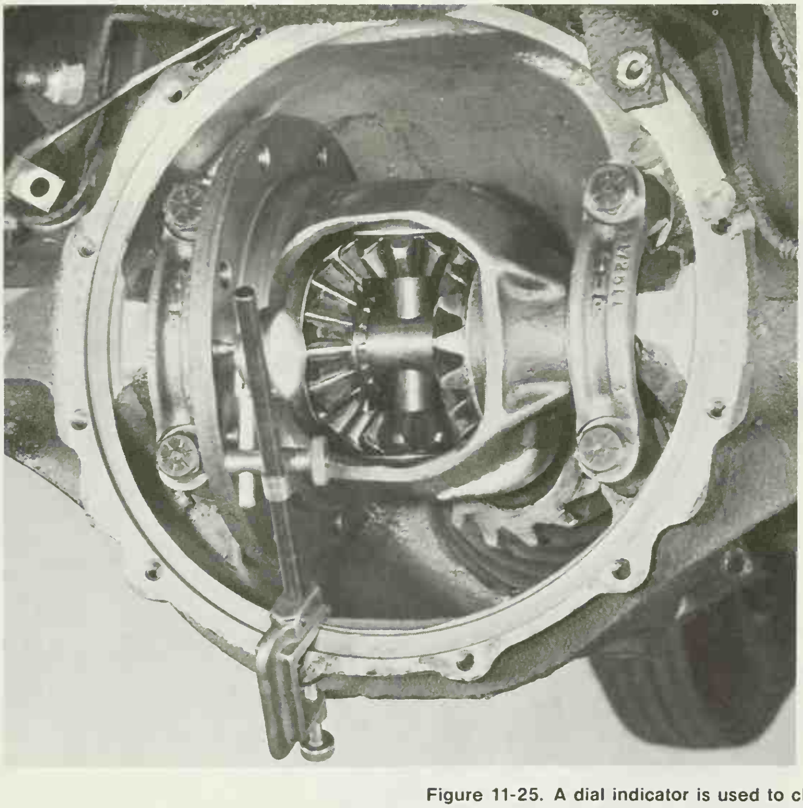


Figure 11-25. A dial indicator is used to check differential case bearings end play and runout. (American Motors Corporation)

Install shims as necessary to adjust bearing end play (Figure 11-26). Be sure to install the same thickness shim at each bearing.

When the bearing end play is eliminated, a slight bearing drag should be noticed. Install bearing cups and tighten bolts to the specified torque. Attach the dial indicator to the axle housing as before and check the ring gear mounting face of the differential **case** for **runout.** Runout must not exceed specifications. Replace the case if the runout exceeds the specified limit. Remove bearing cups and remove the differential assembly. Retain the shims used to eliminate bearing side play.

Position the ring gear on the differential case and align the bolt holes. Install the ring gear attaching bolts and tighten the bolts alternately and evenly to set the gear on the case. Tighten the ring gear bolts to the specified torque.

JOB COMPETENCY 11-11 INSTALL CASE AND ADJUST BACKLASH

The case is now ready for final assembly in the carrier. Some ring and pinion gear sets are the hunting type. Before proceeding, check the gear set timing. The marks on the ring gear should mesh with the mark on the drive pinion. The timing marks may be paint marks and/or a grind notch on the step of the ring gear. They can easily be seen when the ring gear is installed in the carrier.

When you install the case in the carrier, you must adjust the **backlash** between the ring and pinion. Backlash is the slight movement back and forth of the ring gear when the pinion gear is held from rotating. Backlash is adjusted on a removable carrier with **side adjusters** on either side of the case bearings. Backlash is adjusted on a unitized carrier by the same shims used to control end play.

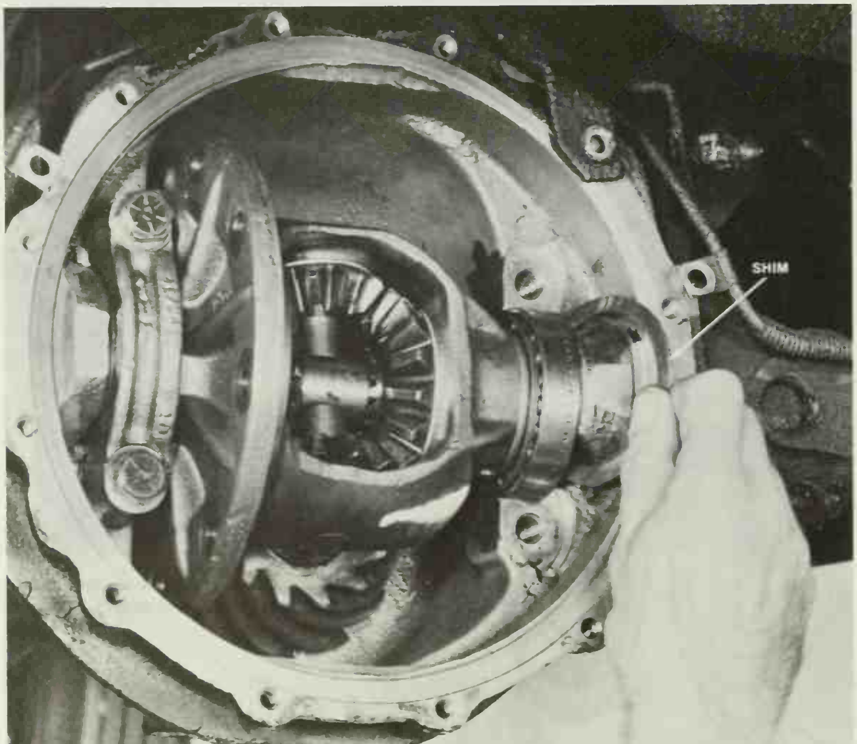


Figure 11-26. Shims are used on a unitized carrier to control bearing end play. (American Motors Corporation)

With a unitized carrier, install the differential assembly and previously selected bearing end play shims in the housing. Install differential bearing cup bolts and tighten the bolts to the specified torque. Mount a dial indicator on the housing as shown in Figure 11-27. Position the indicator stylus so that it contacts the drive side of the ring gear tooth at a right angle to the tooth. Move the ring gear backward and forward and note the backlash registered on the dial indicator. Backlash should follow the manufacturer's specifications. If necessary adjust backlash as follows: To increase backlash, install a thinner shim at ring gear side of case and a thicker shim at the opposite side. To decrease backlash, reverse the procedure. However, do not change total thickness of shims.

For example, the bearing side play was removed with 0.090 inch (2.28 mm) shims on each side totaling 0.180 inch (4.57 mm). Backlash is checked and found to be 0.011 inch (0.28 mm). To correct the backlash, add 0.004 inch (0.10 mm) to shims at the ring gear side of the differential and subtract the same amount from shims at the opposite side. Backlash will be approximately 0.007 to 0.008 inch (0.18 to 0.20 mm). However, the total shim thickness remains at 0.180 inch (4.57 mm).

To adjust the backlash on a removable carrier, the bearing cups which mount over the carrier bearings are not tightened securely so the adjusters may be used to move the ring gear. Positioning the ring gear as far into the pinion as possible removes the play or backlash between the two gears. Positioning the ring gear away from the pinion increases

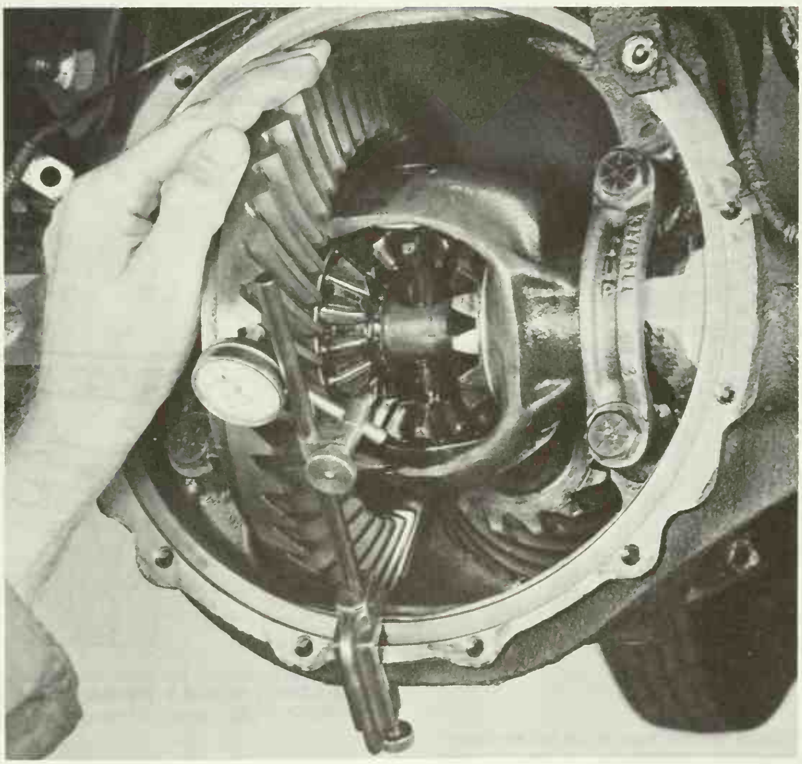


Figure 11-27. Rocking the ring gear back and forth against the dial indicator with the drive pinion held will indicate backlash. (American Motors Corporation)

the backlash (Figure 11-28). When the backlash is set, tighten the side adjuster and bearing cups to the specified amount.

JOB COMPETENCY 11-12 CHECK RING AND PINION GEAR TOOTH CONTACT PATTERN AND REPLACE ASSEMBLY

For a final check to determine if pinion depth and backlash adjustment have brought the ring and pinion into proper mesh, observe the gear tooth contact patterns. First, coat the ring and pinion gear with a thin film of yellow ferric (iron) oxide or titanium white paste. Rotate the pinion gear through one complete revolution. This action will leave a distinct contact pattern on the ring gear.

The side of the ring gear tooth which curves outward, or is convex, is called the "drive" side. The concave side is the "coast" side. The end of the tooth nearest the center of the ring gear is the "toe" end. The end of the tooth farthest away from the center is the "heel" end. The toe end of the tooth is smaller than the heel end (Figure 11-29). Variations in the carrier or pinion rear bearing may cause the pinion to be too far from or close to the ring gear. Thus, the tooth contact must be tested and corrected, if necessary, or the gears may be noisy.

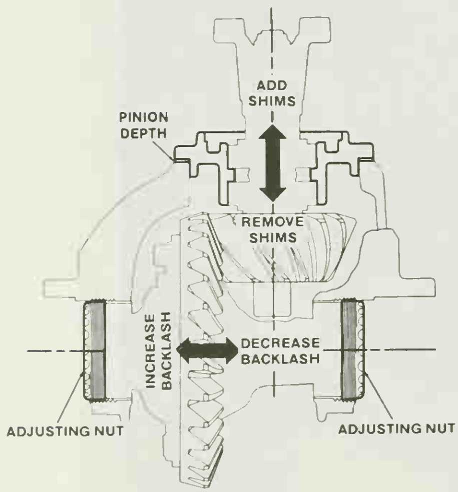


Figure 11-28. Side adjusters are used to set backlash on a removable carrier. (Ford Motor Company)

Wipe oil out of the carrier and carefully clean each tooth of the ring gear. Use gear marking compound and apply this mixture sparingly to all ring gear teeth, using a medium stiff brush. When properly used, the area of pinion tooth contact will be visible when hand load is applied. Turn the pinion flange with a wrench so that the ring gear rotates one full revolution, then reverse rotation so that the ring gear rotates one revolution in the opposite direction. Observe the pattern on the ring gear teeth and compare with a pattern chart similar to that shown in Figure 11-30. If the contact pattern is not correct, follow the directions indicated on the chart. The backlash or pinion depth may require a change to get an acceptable pattern.

After a correct tooth pattern check, when final adjustments are finished, replace the removable differential assembly in the housing. Use a new gasket between the carrier and housing. On a unitized carrier, replace the rear cover with a new gasket. Install the axles, brakes, and wheels. Fill the carrier with the correct type of lubricant. Lower the vehicle and road-test. Check for proper operation and leaks.

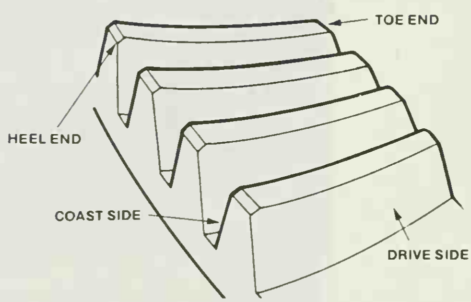


Figure 11-29. Parts of a ring gear tooth. (Nissan Motor Corporation in USA)

JOB COMPETENCY 11-13 SERVICE A CONE CLUTCH LIMITED-SLIP DIFFERENTIAL CASE

When diagnosis indicates a problem in a cone clutch limited-slip differential, the unit must be removed for service. The removal procedures are the same as for a conventional case. In this section we will present the service procedures for this differential.

Remove the ring gear from the case by removing the bolts and then by alternately tapping on the gear with a brass drift. Do not pry between the case and ring gear. Remove the differential case half attaching bolts. Lift the cup half of the case from the flange half. Remove the clutch cone/side gears, spring blocks, preload springs, pinion gears, and shaft. Be certain that each clutch cone/side gear and pinion gear are marked so they can be installed in their original location. Clean the parts in solvent and allow them to dry on a clean shop towel. Inspect the pinion shaft, pinion and side gears, brake cone surfaces, and corresponding cone seats in the case. The cone seats in the case should be smooth and free of any excessive scoring. Slight grooves or scratches, indicating passage of foreign material, are permissible and normal. The top surface on the heavy spirals of male cones will duplicate the case surface condition. If the case or clutch cone/side gears are damaged, it is necessary to replace the case assembly. All other parts are serviceable.

Install the proper cone/gear assembly, seating it into position in the cup half of the case as shown in Figure 11-31. Be certain that each cone/gear is installed in the proper case half, since tapers and surfaces become matched and their positions should not be changed.

Place on spring block in position over the gear face, in alignment with the pinion gearshaft grooves. Install the pinion shaft, pinion gear, and thrust washers into the cup half of the differential case in such a manner that the pinion shaft retaining dowel can be inserted through the pinion gearshaft into

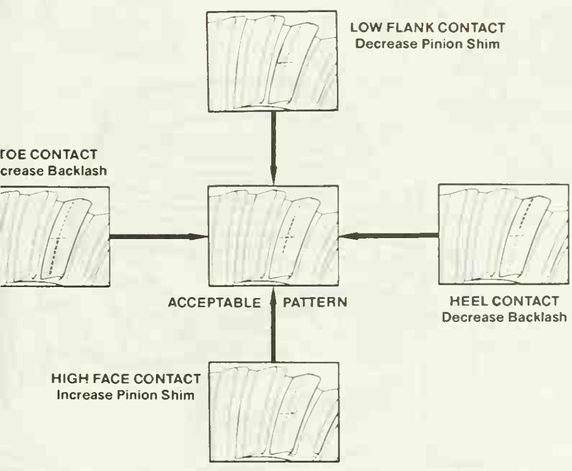


Figure 11-30. The gear tooth pattern is compared to a pattern chart to determine if a correction is necessary. (Cadillac Motor Car Division of General Motors Corporation)

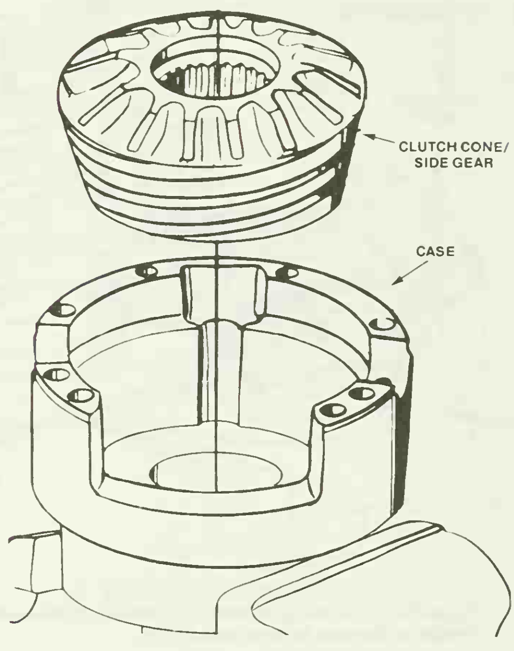


Figure 11-31. Installing the cone/gear assembly. (Pontiac Motor Division of General Motors Corporation)

the differential case. As shown in Figure 11-32, the retaining dowel prevents the pinion shaft from sliding out and causing damage to the carrier. Be sure that the pinion gears are installed in their original location.

Insert the springs into the spring block that is already installed in the case. Then place the second spring block over the springs as shown in Figure 11-33. Install the second cone/gear assembly face-down on the spring block so that the gears will mesh with the pinion gears. Install the flange half of the differential case over the cone, insert case bolts finger tight (Figure 11-34). Tighten the bolts alternately and evenly to the manufacturer's specified torque.

After making sure that the matching surfaces are clean and free of burrs, position the ring gear on the case so that holes are in line. Lubricate the attaching bolts with clean engine oil and install. Pull the ring gear onto the case by alternately tightening the bolts around the case. When all bolts are snug, tighten the bolts evenly and alternately to the correct torque. Install the case in the carrier.

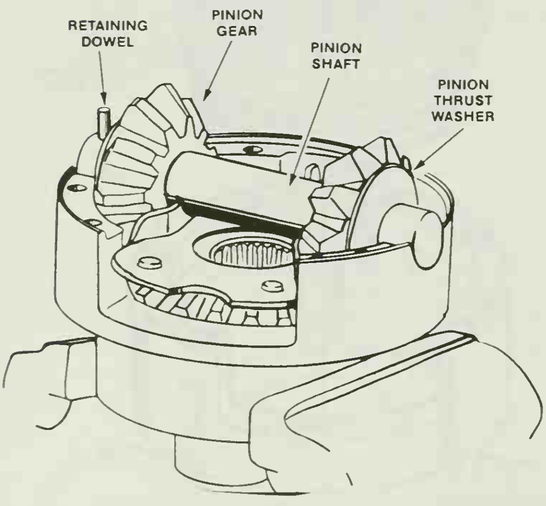


Figure 11-32. Installing parts in the case half. (Pontiac Motor Division of General Motors Corporation)

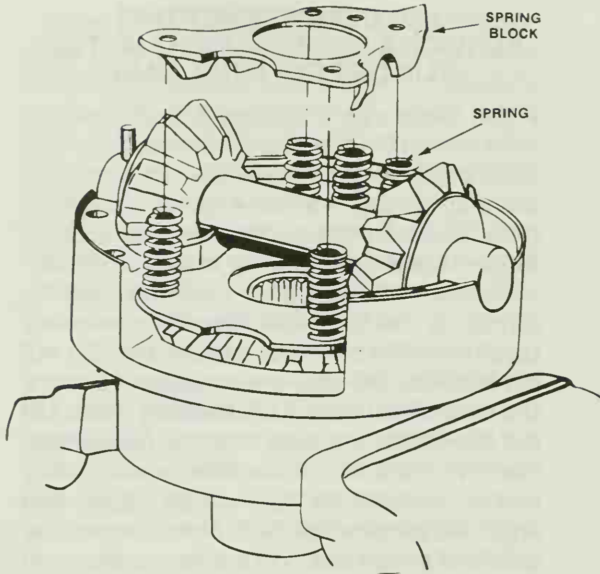


Figure 11-33. Installing the spring block. (Pontiac Motor Division of General Motors Corporation)

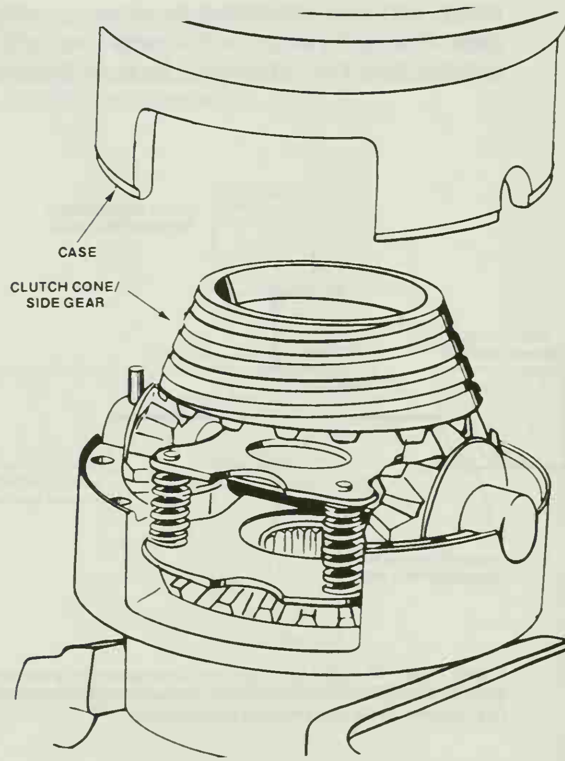


Figure 11-34. Installing the flange half of the case. (Pontiac Motor Division of General Motors Corporation)

JOB COMPETENCY 11-14 SERVICE A MULTIPLE-DISC LIMITED-SLIP DIFFERENTIAL CASE

The multiple-disc limited-slip differential case is removed and replaced like a conventional unit. In this section we will present the procedures used to service this type of case.

When the case has been removed, drive the preload spring retainer and springs through the observation hole in the case only far enough to secure a C-clamp as shown in Figure 11-35. Then install bolts through the retainers and secure enough to remove the retainer and spring pack. If it is necessary to disassemble the retainer and spring, position in a vise and remove the bolts and C-clamp. Loosen the vise until the spring compression is relieved. Remove the pinion thrust washers from behind the pinion gears. Remove the pinion gears from the case. Pinion gears can be removed by rotating them in one direction only.

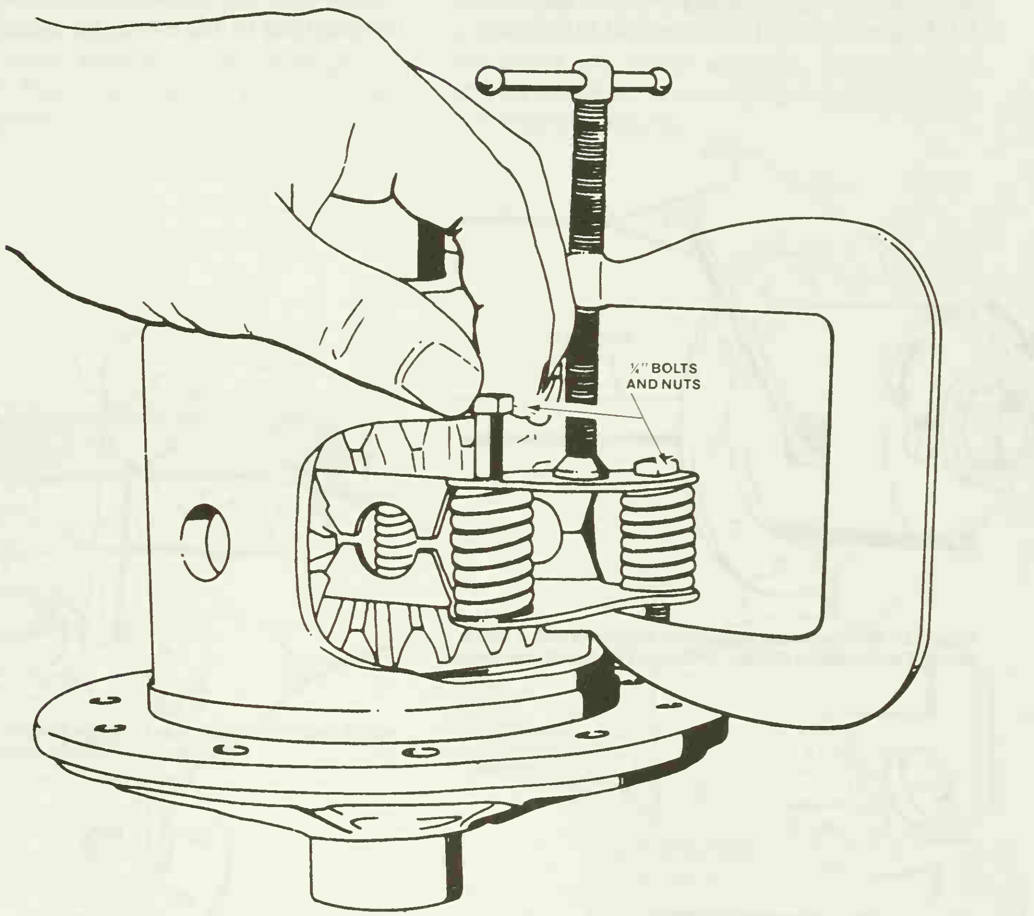


Figure 11-35. Removing preload springs and retainers. (Pontiac Motor Division of General Motors Corporation)

Rotate the differential case clockwise as shown in Figure 11-36 to remove the first gear. Then rotate the case counterclockwise to remove the second gear. To remove the second gear, it may be necessary to use a screwdriver to push the pinion gear on its seat.

Remove the side gear, clutch pack, shims, and guides from the case. Tap the assembly from the case, using a brass drift as shown in Figure 11-37. Repeat the removal on the opposite gear. Separate the clutch pack assembly from the side gear. Retain the clutch pack assembly with the original side gear.

Clean the side bearings thoroughly in clean solvent and let them dry. Examine the bearings visually and by feel. Oil and rotate the bearings, applying as much hand pressure as possible. They should feel smooth. Minute scratches and pits that appear on rollers and races at low mileage are due to the initial preload, and bearings having these marks should not be replaced. Inspect the clutch plates for scored, worn, cracked, or a distorted condition. If any of these conditions exist, new clutch plates must be installed.

Lubricate clutch plates and discs with the correct type of lubricant. Alternately position

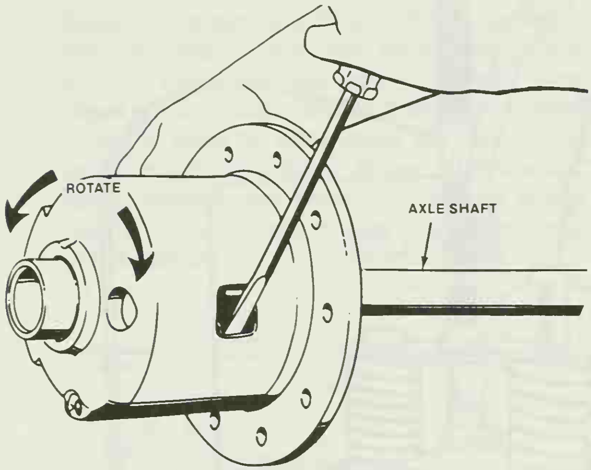


Figure 11-36. Removing the pinions by prying with a screwdriver. (Pontiac Motor Division of General Motors Corporation)

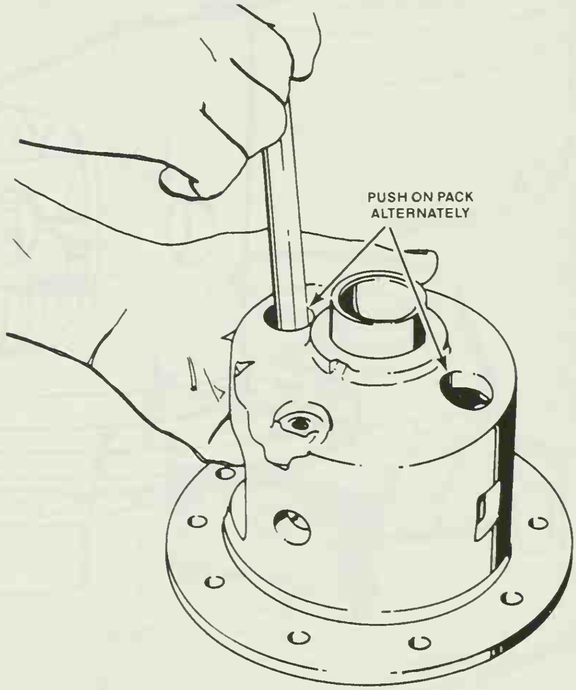


Figure 11-37. The clutch pack is removed by tapping with a brass drift. (Pontiac Motor Division of General Motors Corporation)

clutch plate and clutch disc on the side gear, beginning and ending with a clutch plate, until assembly of clutch pack is completed as shown in Figure 11-38. Install clutch pack guides on the clutch plate lugs. Make sure that the clutch disc lugs engage with side gear teeth.

Select shims the same thickness as those removed from the case, or if old shims are suitable, reinstall them over the side gear hub. Lubricate and assemble the opposite side gear as above. Install one side gear, the clutch pack assembly, and the shim(s) in the differential case. Position the pinion gears and thrust washers on the side gears and install the pinion shaft through the case and gears.

Install a dial indicator on the case so that the stylus rests against the pinion gear as shown in Figure 11-39. Compress the clutch pack, using a screwdriver. Move the pinion gear to obtain tooth clearance. The tooth clearance should be correct to specifications. If required, change shims to obtain proper tooth clearance.

Remove the side gear assembly and repeat the tooth clearance procedure for the gear on the opposite side of the case. Remove the pinion shaft, gears, and thrust washers. Install the remaining side gear, clutch pack assembly, and shims in the case. Install pinion gears and thrust washers. Pinion gears can be installed by reversing the pinion gear removal procedure.

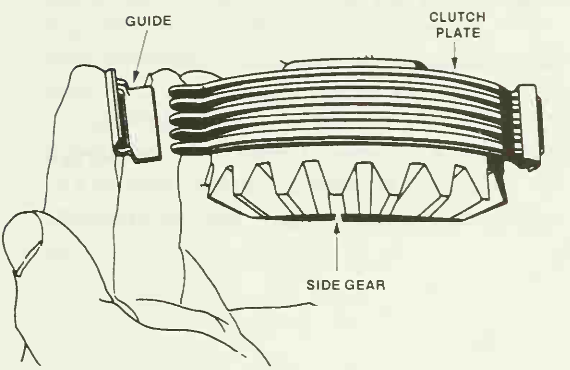


Figure 11-38. Installing clutch pack guides. (Pontiac Motor Division of General Motors Corporation)

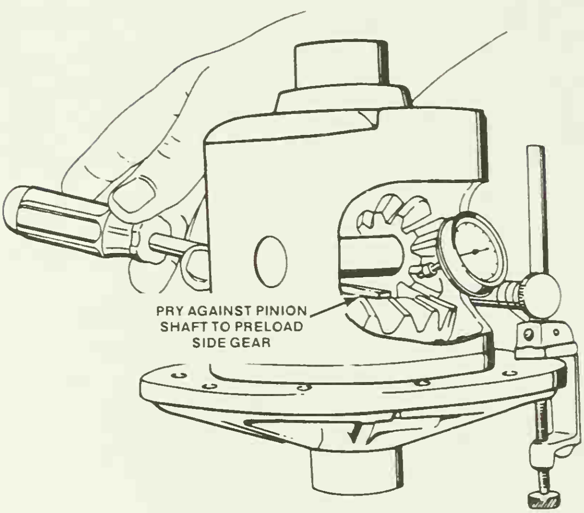


Figure 11-39. Measuring pinion to side gear backlash or clearance. (Pontiac Motor Division of General Motors Corporation)

Assemble springs in the spring retainer and clamp the assembly in a vise. Install a C-clamp and bar stock on the spring retainer. Then install a bolt and nut in each front spring. Position the spring pack between the side gears and remove the bar stock and C-clamp. Drive the spring pack into the side gear enough to retain the front springs, then remove the bolts from springs. Drive the spring pack into position.

Check the alignment of the spring retainer with the side gears. A slight movement of the spring pack can be made if necessary. Install the side bearings and ring gear to the case (if they were removed), using the procedure outlined for the conventional differential.

NEW TERMS

Backlash The space or clearance between the teeth of the drive pinion and ring gear.

Case runout The amount of runout on the ring gear mounting surface of a case.

Differential bearing end-play The amount of side-to-side movement of the differential case controlled by shims between bearings and housing.

Nominal dimension A standard measurement between the end of the pinion and the axle center line used to calculate pinion depth.

Pattern chart Chart showing typical gear tooth contact patterns.

Pinion depth The position of the drive pinion in relation to the axle center line.

Pinion marking Etched marking that identifies pinion match to ring gear and shows desired pinion depth.

Pinion preload The amount the pinion shaft nut is tightened to preload the pinion bearings. Measured with a torque wrench.

Side adjusters Threaded adjusters on each side of a removable carrier case, used to set backlash.

Spreader Tool used to spread the housing of a unitized carrier to remove the case.

Standard setting Same as nominal dimension.

JOB COMPETENCY TEST

1. How is lubricant removed from a differential that does not have a drain plug?
2. How is a limited-slip differential tested for proper operation?
3. Why is the pinion bearing preload measured prior to removing a pinion seal?
4. Why is a spreader used to remove a case from a unitized carrier?
5. How is pinion depth adjusted?
6. What do the markings on the pinion show?
7. What is the standard setting?
8. How is pinion bearing preload measured?
9. How is the ring and pinion backlash measured?
10. What does the ring and pinion gear tooth contact show?

CERTIFICATION PRACTICE

1. A differential makes a clunk noise. Mechanic A says the problem may be ring and pinion clearance. Mechanic B says the problem may be loose-fitting side gears. Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. Before removing a pinion seal, the mechanic should measure:
   a. Depth
   b. Preload
   c. Case runout
   d. Differential bearing end play
3. Prior to removing a carrier the mechanic must remove:
   a. Drive wheels
   b. Drive axles
   c. Both a and b
   d. Neither a nor b
4. A spreader is used to remove the case from:
   a. Unitized carrier
   b. Removable carrier
   c. Both a and b
   d. Neither a nor b
5. Pinion depth is adjusted with shims on:
   a. Pinion shaft
   b. Case
   c. Both a and b
   d. Neither a nor b
6. Markings on the pinion show:
   a. Match to ring gear
   b. Pinion depth variance
   c. Both a and b
   d. Neither a nor b
7. A differential has a damaged ring gear. Mechanic A says only the ring gear must be replaced. Mechanic B says both a ring gear and a pinion must be replaced. Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
8. Pinion bearing preload is measured with:
   a. Dial indicator
   b. Inch-pound torque wrench
   c. Foot-pound torque wrench
   d. None of the above
9. A gear tooth contact pattern will check for correct:
   a. Backlash
   b. Pinion depth
   c. Both a and b
   d. Neither a nor b
10. The closer the ring gear is to the pinion gear:
    a. The larger the backlash
    b. The smaller the backlash
    c. The higher the preload
    d. The lower the preload

ANSWERS:

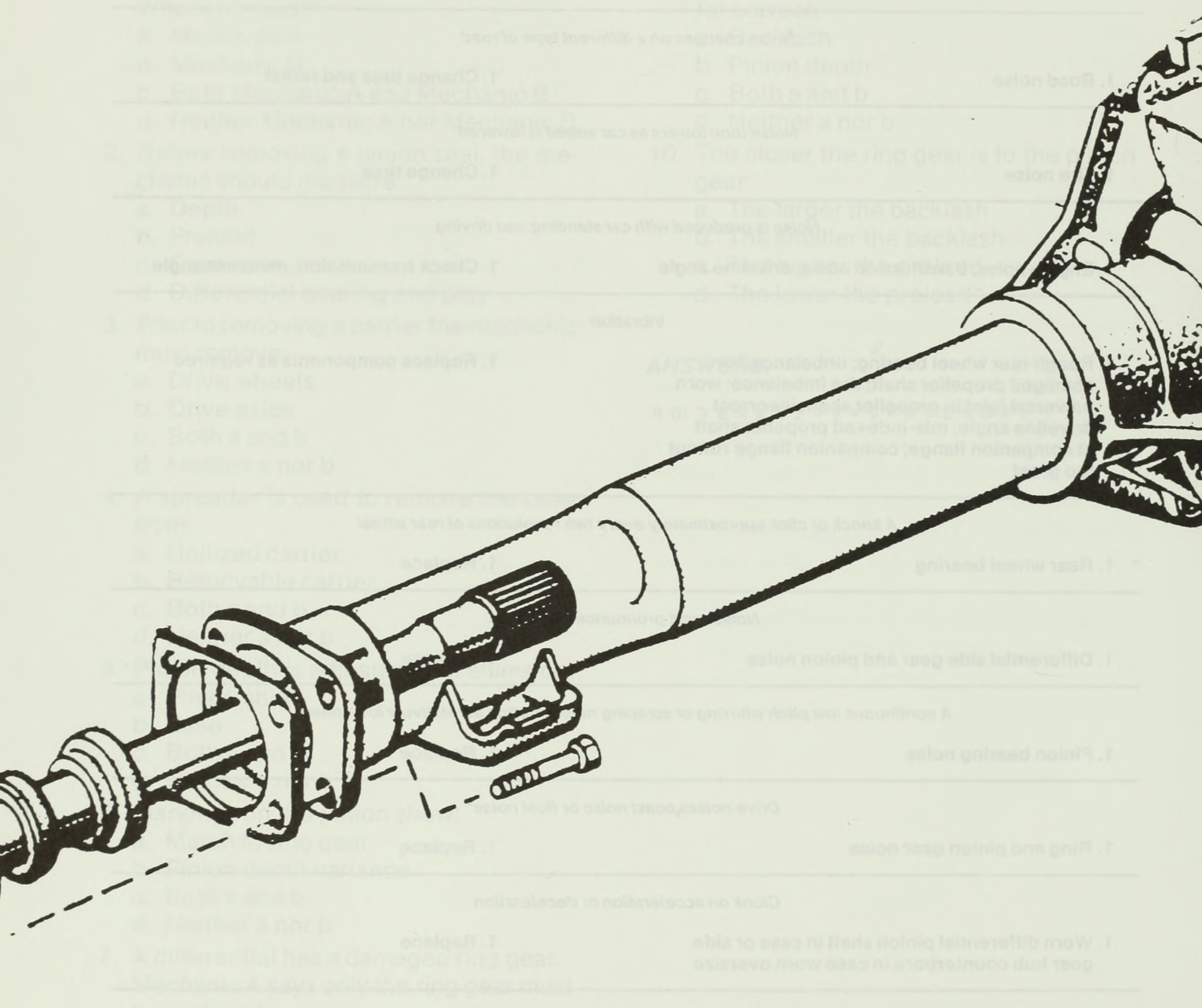
1. c, 2. b, 3. c, 4. a, 5. a, 6. c, 7. b, 8. b, 9. c, 10. b

DISCUSSION TOPICS AND ACTIVITIES

1. Road-test a vehicle with a differential problem and try to isolate the problem.
2. Disassemble, reassemble, and adjust a shop differential.

DIFFERENTIAL TECH CHECK

Possible Cause	Service
Noise is the same in drive or coast	
1. Road noise; tire noise; front wheel bearing noise; incorrect driveline angle	1. Change tire pressure and road test
Noise changes on a different type of road	
1. Road noise	1. Change tires and retest
Noise tone lowers as car speed is lowered	
1. Tire noise	1. Change tires
Noise is produced with car standing and driving	
1. Engine noise; transmission noise; driveline angle	1. Check transmission; measure angle
Vibration	
1. Rough rear wheel bearing; unbalanced or damaged propeller shaft; tire imbalance; worn universal joint in propeller shaft; incorrect driveline angle; mis-indexed propeller shaft at companion flange; companion flange runout too great	1. Replace components as required
A knock or click approximately every two revolutions of rear wheel	
1. Rear wheel bearing	1. Replace
Noise most pronounced on turns	
1. Differential side gear and pinion noise	1. Replace
A continuous low pitch whirring or scraping noise starting at relatively low speed	
1. Pinion bearing noise	1. Replace
Drive noises, coast noise or float noise	
1. Ring and pinion gear noise	1. Replace
Clunk on acceleration or deceleration	
1. Worn differential pinion shaft in case or side gear hub counterbore in case worn oversize	1. Replace
Groan in forward or reverse	
1. Wrong lubricant in differential	1. Drain and refill
Chatter on turns	
1. Wrong lubricant in differential 2. Clutch plates worn	1. Drain 2. Replace
Clunk or knock on rough road operation	
1. Excessive end play of axle shafts	1. Replace



Unit 12
Drive Axle

The torque developed by the engine must be directed to each of the vehicle's driving wheels. Up to this point we have traced the flow of power through the clutch, transmission, and differential. Power flows from the differential assembly to the front or rear drive wheels through drive **axles.** As we will see, drive axles are designed differently for transaxle assemblies than for those used for separate differential units.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe the purpose of a drive axle.
2. Describe the parts of a semifloating drive axle.
3. Explain how a full-floating drive axle differs from a semifloating axle.
4. Describe the special requirements of a front-drive axle.
5. Describe the parts and explain the operation of the two joints used on a front-drive axle.

REAR-DRIVE AXLES

When the vehicle uses a front engine and a rear drive, the drive axles are typically mounted in the same housing as the differential. There is a drive axle for each rear wheel. The axle is a long round bar of high quality steel. One end of the drive axle is splined to fit into the differential axle side gear. The other end of the axle has a flange formed on the end. The flange has studs mounted on it that are used to drive the

wheel. An exploded view of a rear-drive axle is shown in Figure 12-1.

At the side gear end of the axle, the splines on the axle enter into the splines on the axle side gears. As the axle side gears are driven by the differential assembly, the axles are driven. Most rear axles do not use any type of retainer at this end of the axle. Some axles, do, however, use a retainer at the side gear end. An axle and retainer assembly is shown

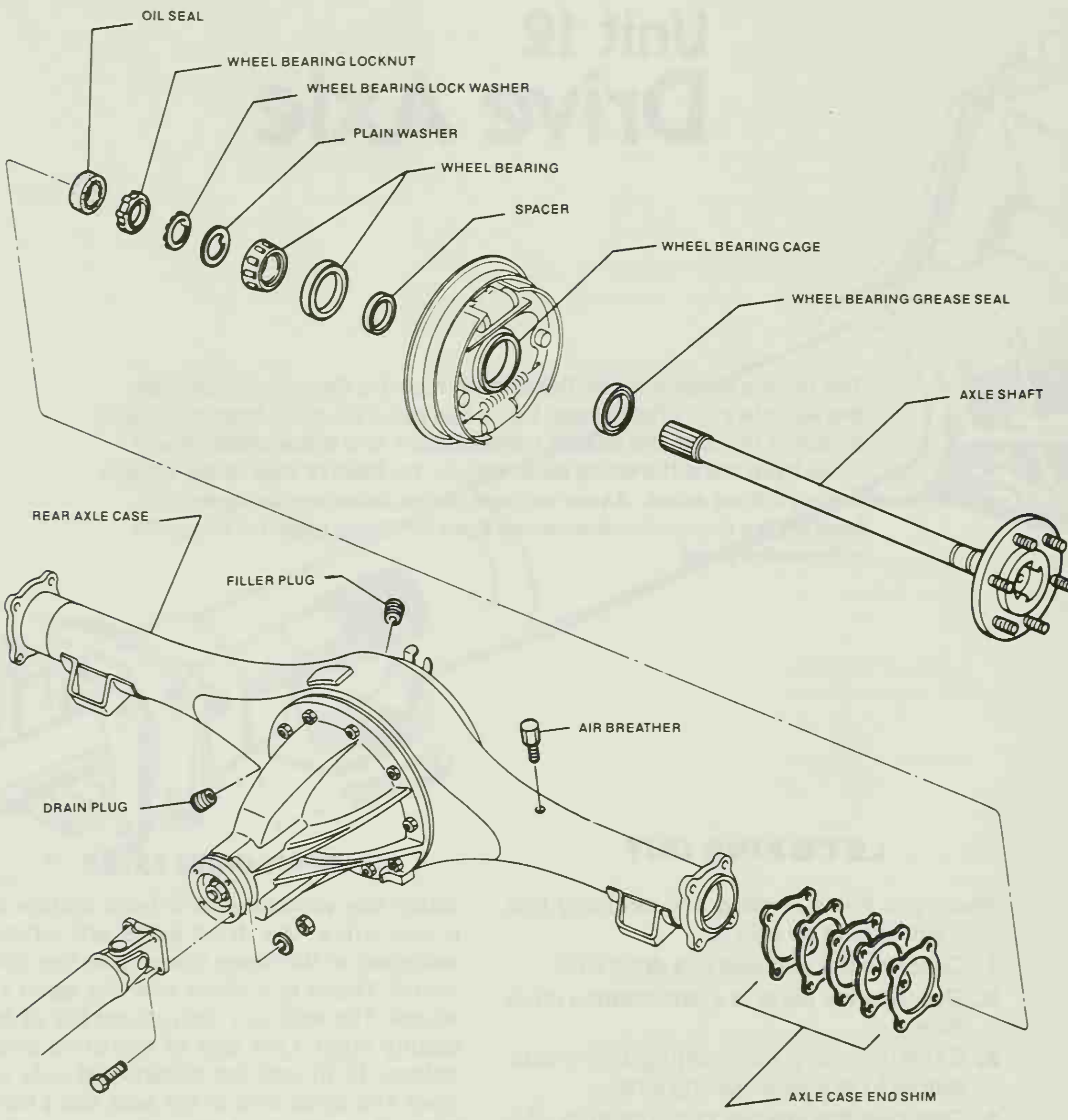


Figure 12-1. Exploded view of a rear-drive axle assembly. (Nissan Motor Corporation in USA)

in Figure 12-2. A groove is machined near the end of the axle. When the axle is in position in the side gear, the end of the axle fits through the gear and into a thrust block. The thrust block fits in the middle of the side gears and differential pinions. The C-lock or retaining ring fits in the axle groove and is seated in the thrust block. This retainer must be removed when removing the axle.

The axle must be supported at either end by **bearings.** At the side gear end the axle is supported in the side gears, which in turn are supported in the differential case. The case bearings support the case and, through the side gears, support the end of the axle shafts.

At the wheel end the axle is supported by a tapered roller, a straight roller bearing, or a ball bearing. On most passenger cars, the bearing assembly fits between the axle shaft and the inside of the axle housing as shown in Figure 12-3. With this arrangement the axle supports part of the weight of the vehicle through the bearing and housing. This type of axle is sometimes called a **semifloating axle.**

The bearing may be sealed or open. A sealed bearing is packed in lubricant during manufacture and has a sealed cover installed over it. An **open bearing** does not use a cover. Lubricant in the differential housing lubricates the open type of bearing.

Regardless of the type of bearing, an oil seal is used to prevent the lubricant from escaping out of the end of the housing. The oil seal has a lip that rides on the rotating axle. This lip prevents the lubricant from getting out of the housing. The seal may be

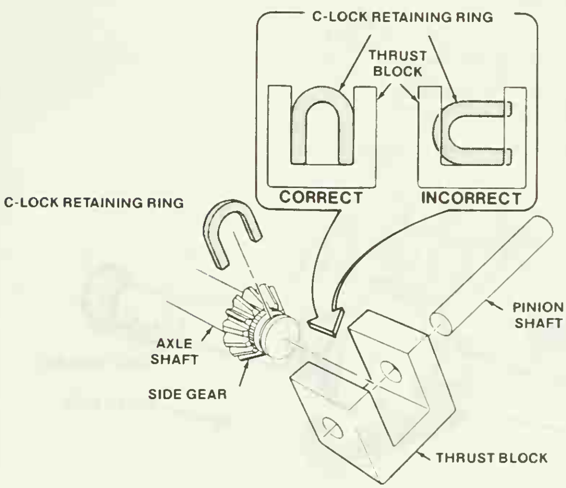


Figure 12-2. An axle may use a retainer at the side gear end. (GMC Truck and Coach Division of General Motors Corporation)

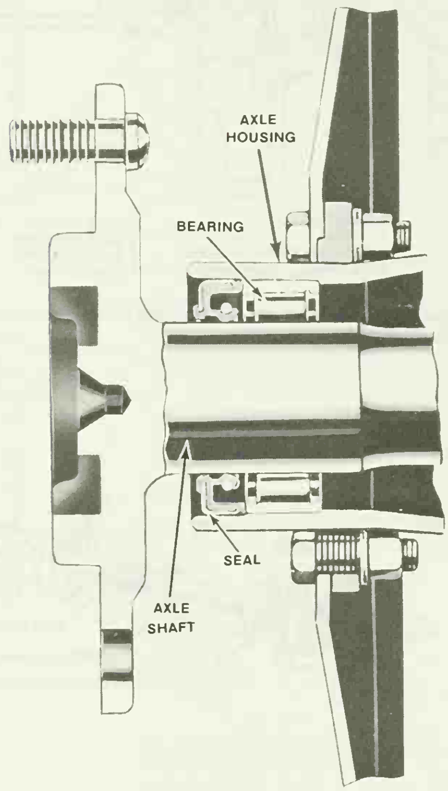


Figure 12-3. The wheel end of the axle is supported in a bearing that fits between the shaft and the housing. (Chevrolet Motor Division of General Motors Corporation)

positioned on the outside of the bearing as shown in Figure 12-3, or it may be installed on the inside of the bearing as shown in Figure 12-4.

One or more **bearing retainers** hold the bearing in position on the axle shaft. The bearing is held on the axle shaft with a press fit between the bearing cup and the axle shaft. Typically an inner retaining ring is pressed on the shaft against the bearing to hold it in place. An outer retainer is bolted to the axle housing to hold the axle in the housing. These parts are shown spread out along the axle in Figure 12-5.

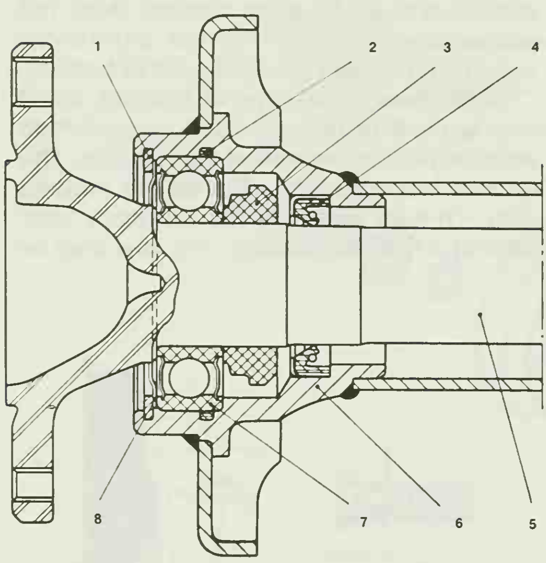


Figure 12-4. This oil seal is installed on the inside of the axle bearing.

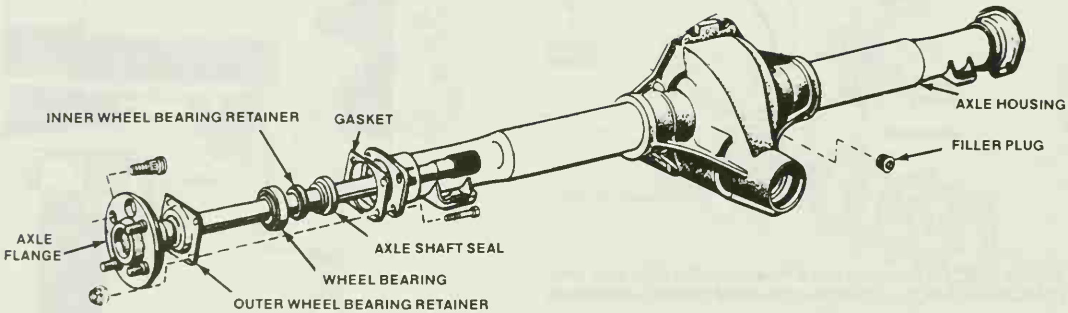


Figure 12-5. The axle bearing is held in place by an inner and outer retainer. (Chevrolet Motor Division of General Motors Corporation)

FULL-FLOATING AXLE

Vans and trucks larger than one-half ton often use an axle arrangement called a full-floating axle. Vehicles which are heavy or used to carry heavy loads cannot use a drive axle that supports part of the vehicle weight. A **full-floating axle** is an arrangement in which the vehicle weight is supported entirely on the axle housing. The axle does not support any vehicle weight.

The wheel on the full-floating type is mounted to a hub assembly. The hub assembly fits on the axle housing. Two tapered roller bearings are used between the hub and the housing. The vehicle weight is supported through the wheel and hub directly on the housing. The drive axle fits through the middle of the hub and, through a series of shaft-to-hub bolts, drives the wheel. The only function of the axle is to provide the driving torque; the axle housing supports the entire weight.

A cross-sectional view of a full-floating axle housing is shown in Figure 12-6. On most wheel hubs with tapered roller bearings, a seal is installed behind the inner bearing to keep the wheel bearing lubricant from getting on the brake lining and brake drum. Bearing preload and end play are adjusted by a nut which threads on the axle housing tube.

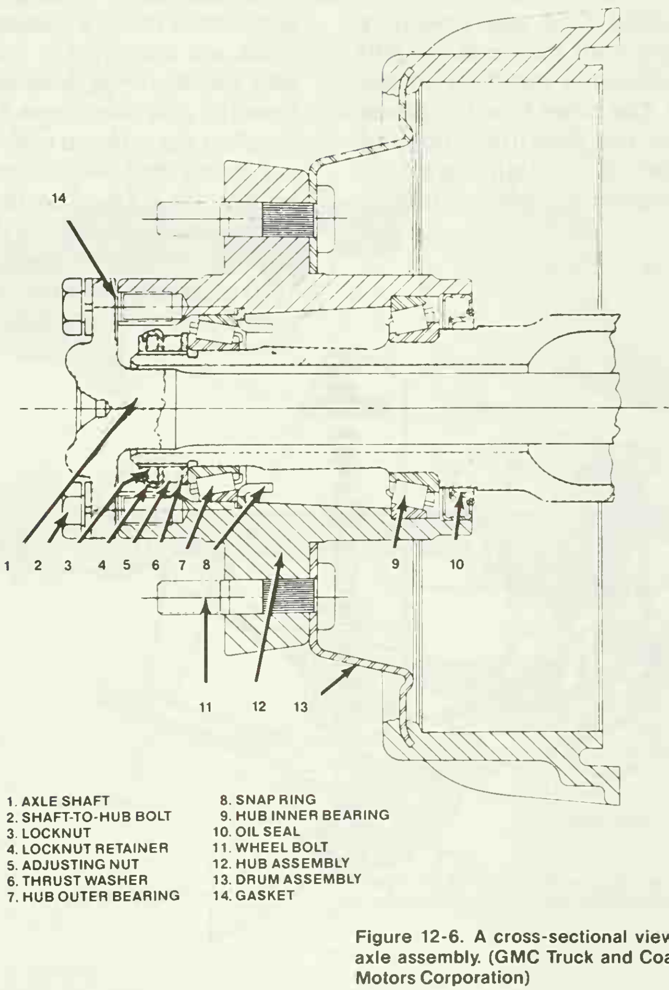


Figure 12-6. A cross-sectional view of a full-floating style axle assembly. (GMC Truck and Coach Division of General Motors Corporation)

Two methods of wheel bearing lubrication are commonly used. On some units the wheel bearings are packed with wheel bearing lubricant. However, axle lubricant can also flow into the wheel hubs and bearings if the axle is tilted. On these axles, wheel bearing grease is the primary lubricant because the grease provides lubrication for the high bearings during extended operation in a tilted condition. The wheel hub is also vented through the axle housing vent.

On other systems, a seal is installed on the front side of the outer wheel bearing so that the axle lubricant cannot flow into the wheel bearing hub and mix with the wheel bearing grease. On these axles, one of two types of seals is used. One seal assembly mounts on the axle shaft flange studs and seals on a wiper which is installed on the axle housing tube. The other type has a seal element built into the bearing adjusting locknut and seals on a ground surface on the axle shaft. The wheel hubs are not vented.

FRONT-DRIVE AXLES

When the vehicle has a front engine and front drive, the drive axles have some special requirements. The front-drive axles operate to transfer the engine's torque from the transaxle to the front drive wheels. The front wheels are used not only to drive the vehicle but also to steer it. The front wheels are attached to the front suspension system as well. The front wheels move from side to side for steering and up and down during suspension action. The transaxle, though, is mounted rigidly to the engine. The front-drive axles must deliver torque to the front wheels while allowing the required wheel movement.

To meet these driving requirements, axle shafts must have two **flexible joints.** The drive axles are engaged in the transaxle at one end, usually by splines which enter the differential axle side gears. This end of the axle is called the inboard end. The axle then runs out to the front hub. The hub is splined to accept the splines on the outboard end of the axle. The axle splines drive the hub which, through the wheel studs, drives the wheel. The relationship of the axles to the front suspension components is shown in Figure 12-7.

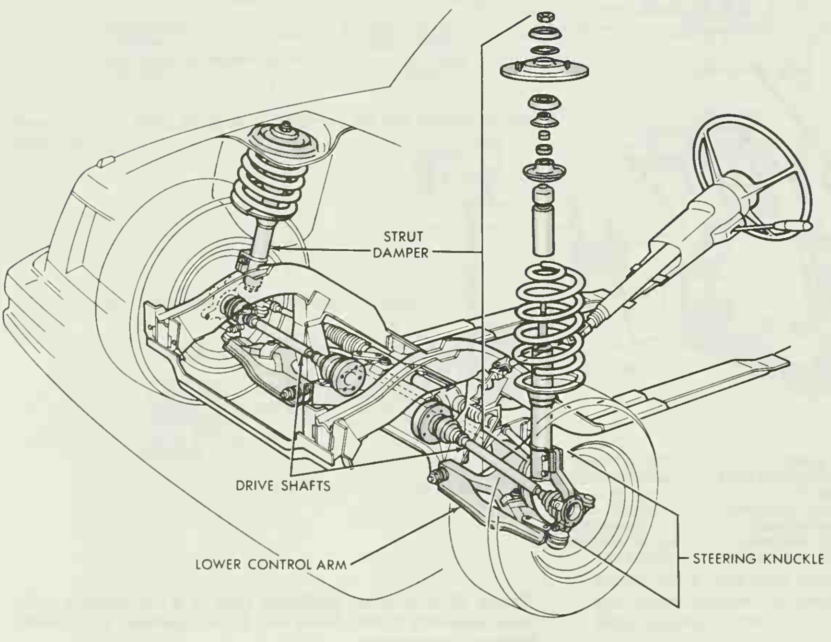


Figure 12-7. The relationship of the front drive axles to the front suspension components. (Chrysler Corporation)

An axle shaft for one side of a front drive is shown is Figure 12-8. The axle shaft is an assembly of three shafts separated by two flexible joints. A short shaft that enters the transaxle is called the inboard shaft. The long shaft in the center is called the center shaft, and the short shaft that drives the hub is called the outboard shaft. The two flexible joints on the shaft each have a separate job to do. The **inboard joint** lets the axle shaft move up and down as the front wheel moves up and down during suspension travel. The **outboard joint** lets the wheel move back and forth for steering.

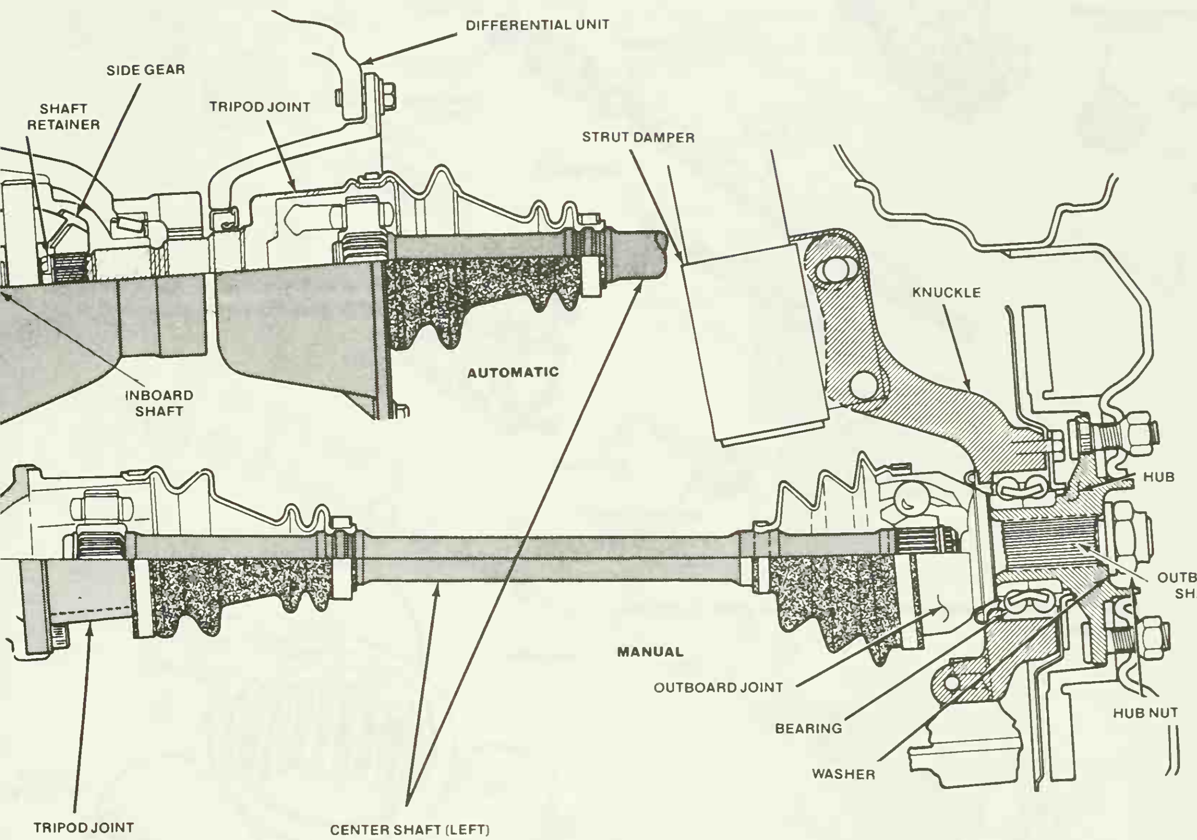


Figure 12-8. A front-drive axle shaft uses three separate shafts and two flexible joints. (Chrysler Corporation)

The most common type of inboard joint is shown in an exploded view in Figure 12-9. The inboard joint shaft has a housing attached to it. The housing has three long channels machined in it. A **tripod** or spider assembly fits into the three channels. The tripod has a splined center which engages the end of the center shaft. Each of the three arms of the tripod has an outer race supported as shown in Figure 12-10 on needle bearings. As the front wheel moves up and down, the three races on the tripod move in and out of the channels of the inboard joint housing, allowing the shaft to change the operating angle. The needle bearings between the race and tripod allow the races to move freely with a minimum of friction. A rubber boot is used to cover and protect the joint assembly.

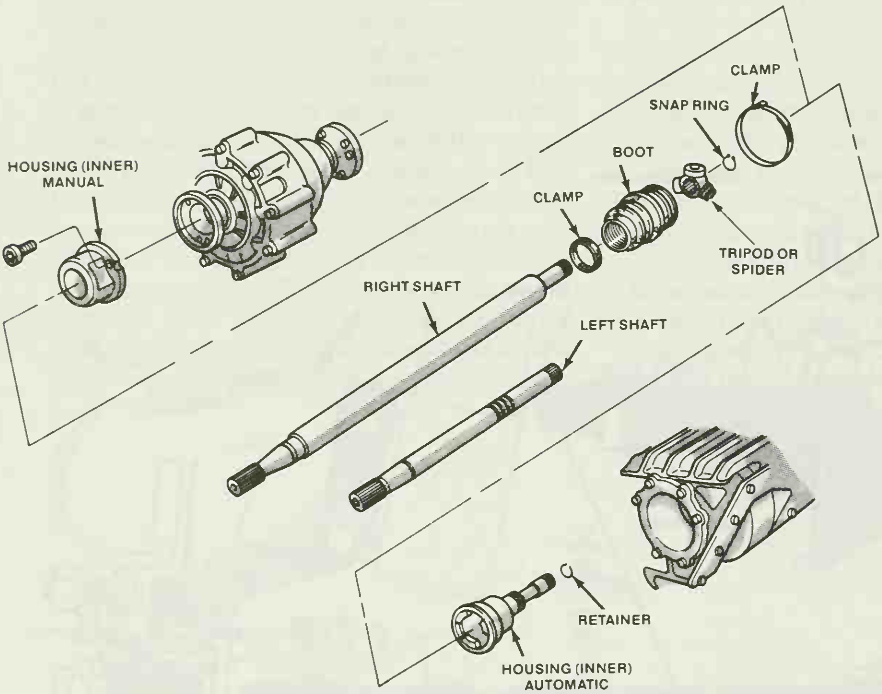


Figure 12-9. Exploded view of an inboard joint. (Chrysler Corporation)

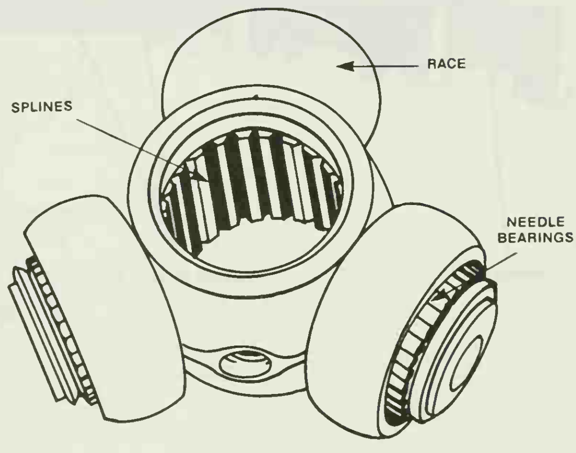


Figure 12-10. The tripod or spider uses three races supported on needle bearings.

The outboard joint consists of an inner race, outer race, a set of balls, and a cage. These parts are shown in an exploded view in Figure 12-11. An inner race with a number of channels is splined to fit on the center axle shaft. A series of hardened steel balls fits into the channels of the inner race. There are matching grooves in the outer race. The cage holds the balls in position when the outer race is assembled over the inner race.

The inner race drives the outer race through the balls. The outer race is part of the outboard shaft. When the outer race is driven, the hub is driven through the hub splines. When the driver turns the front wheels for steering, the outer race can move back and forth because the drive balls can move back and forth in their channels. This outboard joint is also covered with a rubber boot for protection. An exploded view of both axle shaft assemblies for a front-drive axle is shown in Figure 12-12.

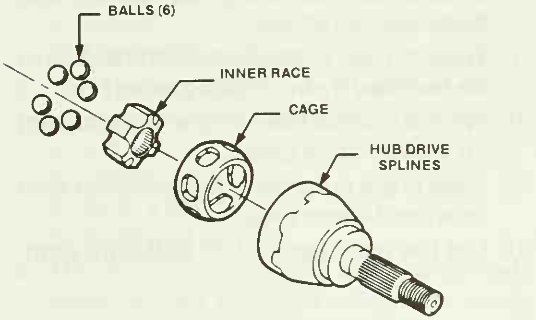


Figure 12-11. An exploded view of an outboard joint. (Pontiac Motor Division of General Motors Corporation)

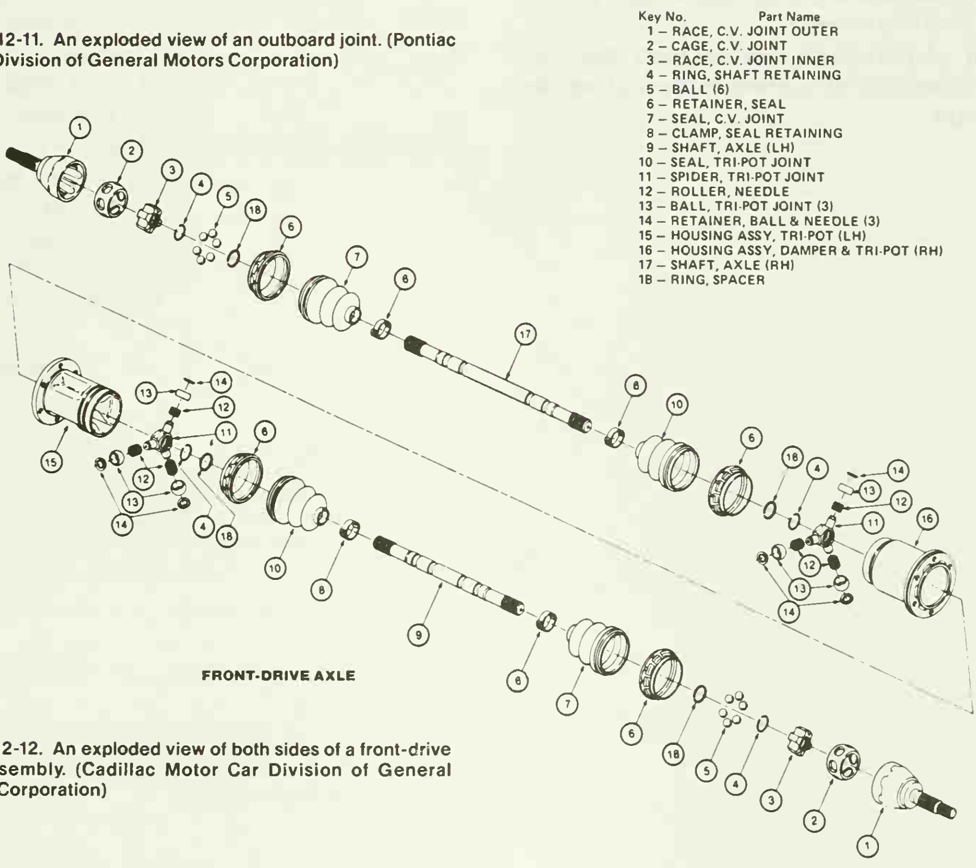


Figure 12-12. An exploded view of both sides of a front-drive axle assembly. (Cadillac Motor Car Division of General Motors Corporation)

NEW TERMS

Axle A shaft used to transfer torque from the differential to a drive wheel.

Axle bearing A bearing used to support an axle shaft in a housing.

Bearing retainer A press or bolt-on device used to hold a bearing in position.

Flexible joints Joints on a front-drive axle which allow the front wheels to turn and move up and down with the suspension.

Full-floating axle An axle system in which all the vehicle weight is supported through a hub to the housing and no weight is supported by the axle.

Inboard joint The inside joint on a front-drive axle which allows for front wheel up and down movement.

Outboard joint The outside joint on a front-drive axle which allows the front wheels to turn back and forth.

Semifloating axle An axle system in which the axle supports the vehicle weight as well as driving the wheel.

Tripod A part of an inboard joint that supports three sets of bearing races and needle bearings.

CHECK YOURSELF

1. What is the purpose of a drive axle?
2. Where is the inside end of a semifloating axle engaged?
3. Where is the axle bearing on a semifloating axle located?
4. What part of a semifloating axle drives the wheel?
5. How does a full-floating axle system support the weight of the vehicle?
6. In what two ways are full-floating hub bearings lubricated?
7. What are two special conditions that must be handled by front-drive axles?
8. What is the purpose of the inboard joint on a front-drive axle?
9. What is the purpose of the outboard joint on a front-drive axle?
10. List the main parts of an outboard joint.

CERTIFICATION PRACTICE

1. The axle system that transfers torque and supports vehicle weight is called:
   a. Front-drive axle
   b. Semifloating axle
   c. Full-floating axle
   d. None of the above
2. The semifloating axle has a bearing between the axle and:
   a. Hub
   b. Housing
   c. Wheel
   d. None of the above
3. The flexible joint in a front-drive axle, which allows the front wheels to turn, is:
   a. Inboard
   b. Outboard
   c. Both a and b
   d. Neither a nor b
4. The flexible joint in a front-drive axle which allows the front wheels to go up and down with the suspension is:
   a. Inboard
   b. Outboard
   c. Both a and b
   d. Neither a nor b
5. Which of the following are components of an outboard joint:
   a. Outer race
   b. Cage
   c. Inner race
   d. All the above

ANSWERS:

1. b, 2. b, 3. b, 4. a, 5. d

DISCUSSION TOPICS AND ACTIVITIES

1. Study the differential assemblies on vehicles in the shop and determine which are semifloating.
2. Place the inboard end of a shop front axle in a bench vise. Move the outboard end up and down and side to side while observing the operation of the flexible joints.

Unit 13
Drive Axle Service

Drive axle problems usually show up as a noise which gets louder during turns. Front-drive axle problems sometimes cause a clunking noise if the inboard joint is worn, or a shudder or vibration during acceleration if the flexible joints are worn or sticking. The diagnosis of drive axle problems is normally done following the procedure described for differential and transaxle troubleshooting. Since the drive axle uses either sealed bearings or sealed joints, there are no preventive maintenance procedures. In this unit we will describe the service procedures used for drive axles.

Service

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

13-1 Remove and replace a rear-drive axle.

13-2 Remove and replace a rear-drive axle seal.

13-3. Remove and replace a rear-drive axle bearing.

13-4. Remove and replace a front-drive axle.

13-5. Overhaul or lubricate a front-drive axle flexible joint.

JOB COMPETENCY 13-1 REMOVE AND REPLACE A REAR-DRIVE AXLE

Raise the rear end of the car and support it with suitable jack stands. **Never work on a car supported solely by a bumper jack.** Remove the hubcap or wheel cover. Remove the wheel lug nuts using a suitable wrench or jack handle. Remove the wheel by pulling straight back. Brush and wipe dirt and grease from the brake drum and brake mechanism.

Examine the area behind the axle flange. Certain Ford- and Chrysler-built vehicles have three or four bolts which, when removed, allow the axle to be pulled with a suitable puller. If these bolts are present, remove them and carefully pull the axle shaft using an axle puller as shown in Figure 13-1. Attach the axle puller to the axle flange and use a slide hammer to pull out the axle.

If these bolts are not present, remove the differential cover and drain the lubricant. Remove the differential pinion shaft lock screw and pinion shaft. Remove any retainer clips, speed nuts, or lock washers. Push the axle shaft in, remove the horseshoe washer from the axle shaft, and pull out the axle.

Push the axle shaft in carefully to avoid damaging the seal. Turn the axle to engage the shaft. Reassemble the differential in reverse order of disassembly if it was disassembled. If it was not, replace the three or four axle retainer bolts.

Check or refill the differential with approved lubricant, taking care not to overfill. Replace the brake drum and rear wheel. Replace the wheel cover or hubcap and lower the car.

If the vehicle is equipped with full-floating axles, it is not necessary to raise the rear wheels in order to remove the rear axle

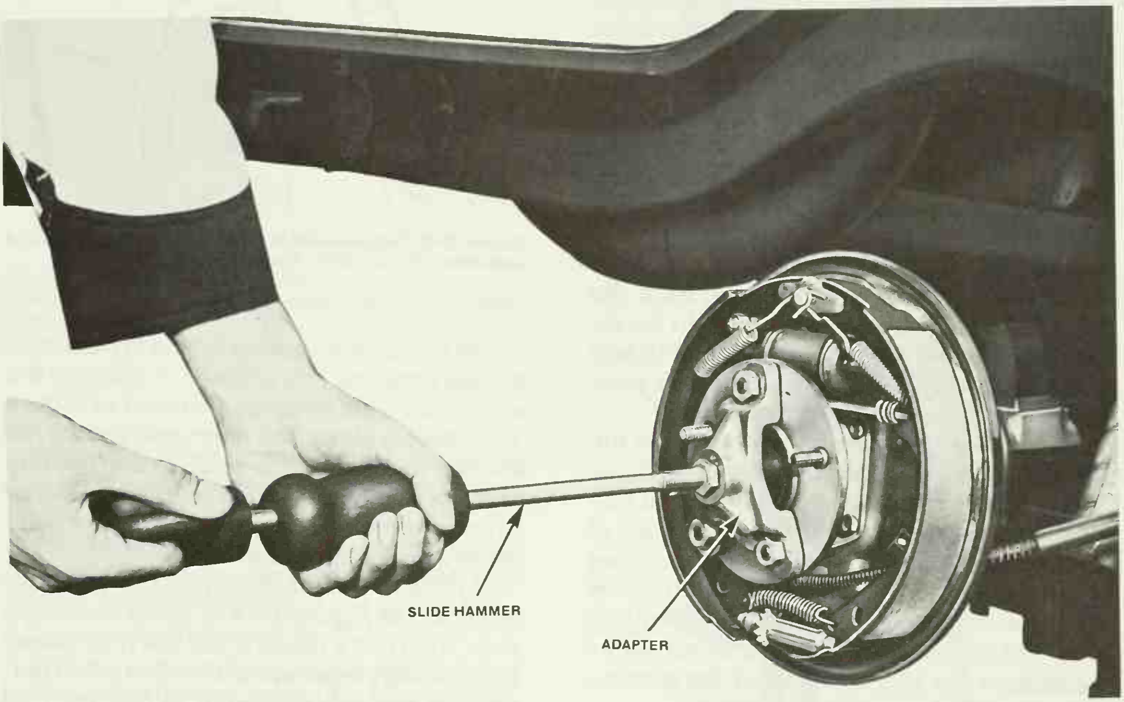


Figure 13-1. An axle puller uses a slide hammer attached to the axle flange. (Chevrolet Motor Division of General Motors Corporation)

shafts. Remove the axle flange nuts, lock washers, and the split washer retaining the axle shaft flange. Remove the axle shaft from the housing.

To install the full-floating axle, be sure that the axle flange mating area on the hub and axle are clean and free of old gasket material. Install the new flange onto the hub studs. Insert the axle shaft into the housing. It will be necessary to rotate the axle shaft to simultaneously align the shaft splines with the differential gear splines and the flange attaching holes with the hub studs. Install the split washers, lock washers, and flange nuts. Tighten nuts securely to the specified torque.

JOB COMPETENCY 13-2 REMOVE AND REPLACE A REAR-DRIVE AXLE SEAL

Rear wheel seals are usually replaced only after considerable mileage. However, it is good policy to replace the rear seals when the brakes are relined or at any time that the differential or rear wheel bearings require removing. The replacement of the rear wheel seal ensures that necessary lubricant from the differential will not leak out past worn seals. A seal should never be reused. Not only is the lip worn but a used seal which has been removed has been distorted and will not seal properly.

Raise the vehicle on a hoist or support it on jack stands. Remove the axle from the housing side in which the seal is to be replaced. Remove the seal with a suitable seal puller to prevent damage to the bore. If available, a slide hammer may also be used.

Check that the replacement seal has the correct outside and inside lip diameter. Apply a thin coating of grease or differential lubricant to the sealing lip and outer edges of the new seal. Slip the new seal on the proper installation tool, placing the side of the seal with the larger opening over the tool into position so that the sealing edge faces away from the tool and toward the bearing when installed.

With the seal in place on the tool, insert the tool into the axle housing. Hold the guiding handle tightly against the housing and push the shaft into the housing. Only a few gentle taps with a rawhide or rubber mallet are needed to bottom the seal against the step inside the axle housing as shown in Figure 13-2. Replace the axle as described previously.

JOB COMPETENCY 13-3 REMOVE AND REPLACE A REAR-DRIVE AXLE BEARING

When diagnosis procedures indicate an axle bearing failure, the bearing is removed and replaced. If the vehicle has high mileage, the mechanic should replace the axle bearing on both sides. Since the bearing is pressed on the axle shaft, the first step is to remove the axle as described previously.

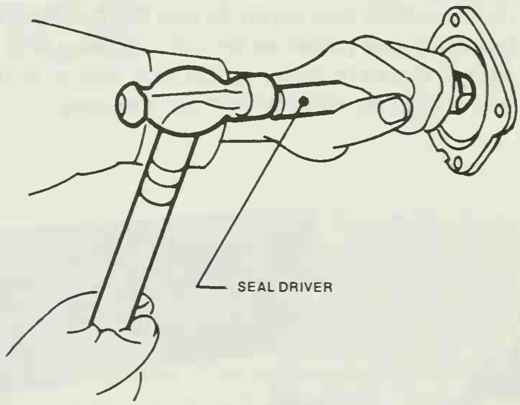


Figure 13-2. The new seal is driven into the housing with a seal driver. (Nissan Motor Corporation in USA)

The typical axle bearing is held in place with a small retaining ring pressed in place on the axle shaft. This retainer is shown in Figure 13-3. **Safety Note:** ***The mechanic should not attempt to press off the retainer and bearing at the same time. The high pressure required to remove the retainer could cause the bearing to shatter and cause injury.***

To remove the retaining ring use a grinder as shown in Figure 13-4 to grind down one side. Then use a chisel to cut the ring. **Safety Note:** ***Always wear eye protection when performing this job.*** Once cut in half the ring can easily be removed from the axle. **Do not use a torch or heat to cut off a bearing or retainer because the heat will damage the axle shaft.**

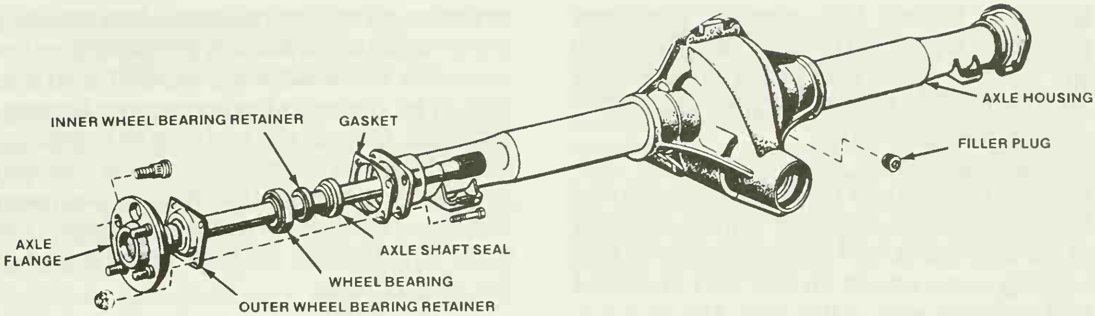


Figure 13-3. The inner retainer must be removed to replace the bearing. (Chevrolet Motor Division of General Motors Corporation)

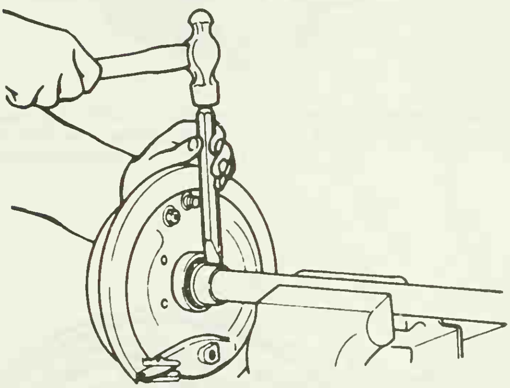


Figure 13-4. The first step in removing the retainer is to cut it with a chisel or grind it down with a grinder. (Nissan Motor Corporation in USA)

With the retainer removed, the axle bearing may be pressed off. Install a press attachment on the axle and place the axle assembly in a press. **Safety Note:** ***Always wear eye protection when pressing bearings, in case they shatter.*** Press on the end of the axle to force it through the bearing (Figure 13-5).

Some axle assemblies have a seal installed between the bearing and outer retainer. This seal is replaced after the bearing is removed. A new bearing is placed on the axle shaft. The axle shaft is pressed through the new bearing as shown in Figure 13-6. A new retainer is pressed on against the bearing as

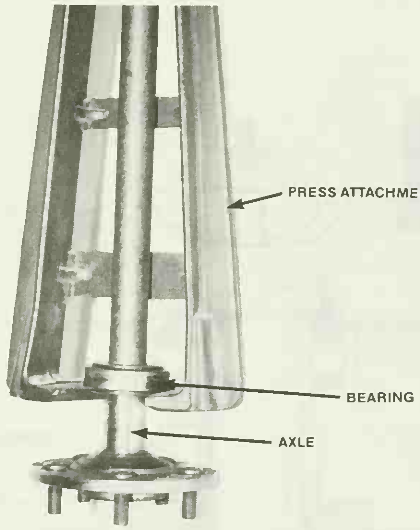


Figure 13-5. The old bearing is pressed off the axle shaft.

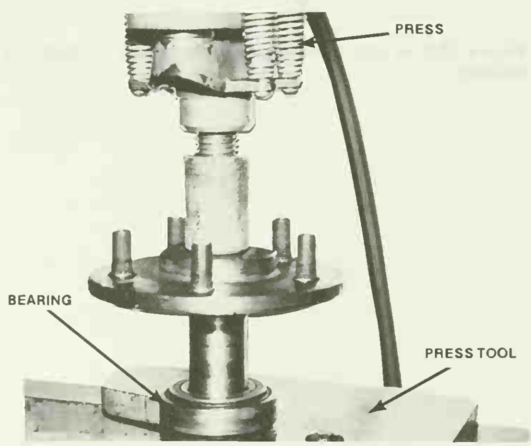


Figure 13-6. The new bearing is pressed on by pressing the axle shaft through the bearing. (Nissan Motor Corporation in USA)

shown in Figure 13-7. Heating the inner retainer in an oil bath to about 150°C (302°F) will require much less press pressure for installation. The axle is ready for installation as described previously.

After installing a new axle or new axle bearing, the **axle end play** must be measured and, if necessary, adjusted. Strike the ends of the axle shafts with a lead hammer to seat bearing cups. Mount an end play checking tool onto the end of the axle. Mount a dial indicator on the end play tool and measure the end play while pushing and pulling on the axle shaft as shown in Figure 13-8. End play should be correct when compared to specifications. Correct the end play as necessary by adding **axle shims** to increase the end play, or by removing the shims to decrease end play. The shims are located between the outer axle bearing retainer and the end of the axle housing.

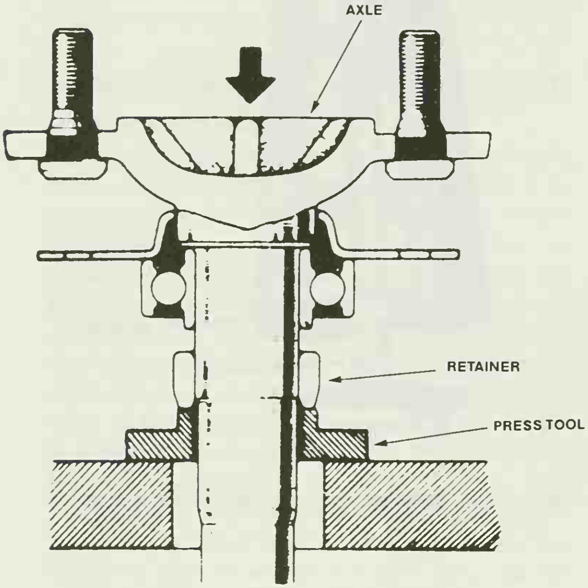


Figure 13-7. A new inner retainer is pressed on after the bearing.

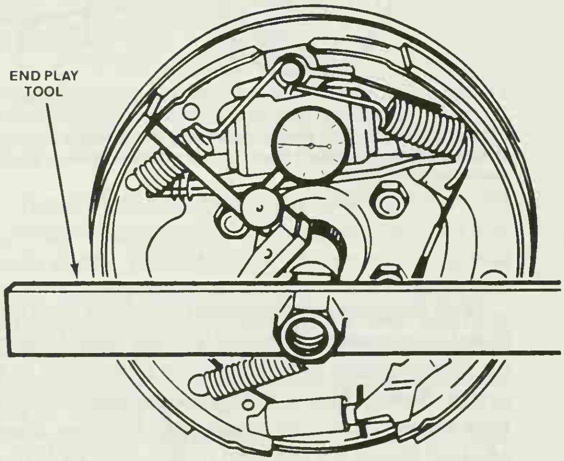


Figure 13-8. Measuring axle shaft end play. (American Motors Corporation)

JOB COMPETENCY 13-4 REMOVE AND REPLACE A FRONT-DRIVE AXLE

When diagnosis procedures indicate a problem with an inboard or outboard flexible joint, the axle must be removed for service. To remove a front-drive axle, remove the hub nut. Raise the car on a hoist or support it on jack stands. Remove the wheel and tire. Install an axle shaft boot seal protector as shown in Figure 13-9.

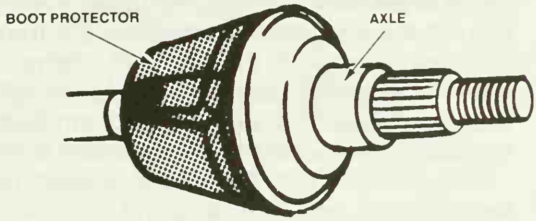


Figure 13-9. A boot protector is installed over the axle shaft boot prior to removal. (Pontiac Motor Division of General Motors Corporation)

Disconnect the brake line clip at the strut. Remove the brake caliper and support the caliper. Mark the cam bolt to ensure proper camber alignment upon reinstallation. Remove the cam bolt and upper attaching bolt. Pull the steering knuckle assembly out of the strut bracket. Use a slide hammer to remove the axle shaft from the transaxle as shown in Figure 13-10.

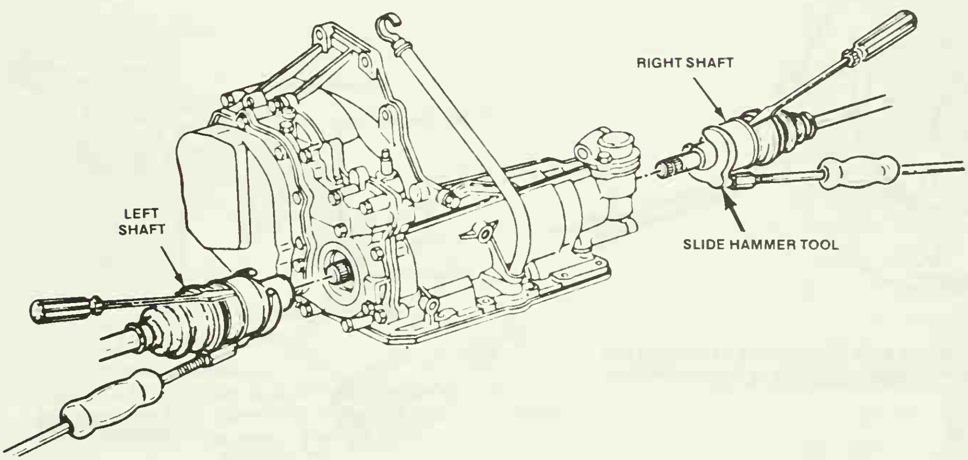


Figure 13-10. A slide hammer pulling tool is used to pull the axles out of the transaxle. (Pontiac Motor Division of General Motors Corporation)

The new or serviced axle assembly is installed by loosely installing the drive axle to the steering knuckle and transaxle. Loosely attach the steering knuckle to the strut bracket. Install the brake caliper. Torque the bolts to specifications. Install the hub nut. When the shaft begins to turn, insert a drift or screwdriver in the slot of the rotor to prevent the turning as shown in Figure 13-11. Torque the nut to specifications.

Apply a load to the hub assembly by lowering the vehicle on jack stands. Align the cam bolt with alignment marks. Torque the nut to specifications. Torque the upper nut to specifications. Install the axle shaft to transaxle using a screwdriver and the groove on the inner retainer. Tap the screwdriver until the shaft is seated into the transaxle. Connect the brake line clip to the strut bracket. Install the tire and wheel. Lower the vehicle and torque the hub nut to specifications.

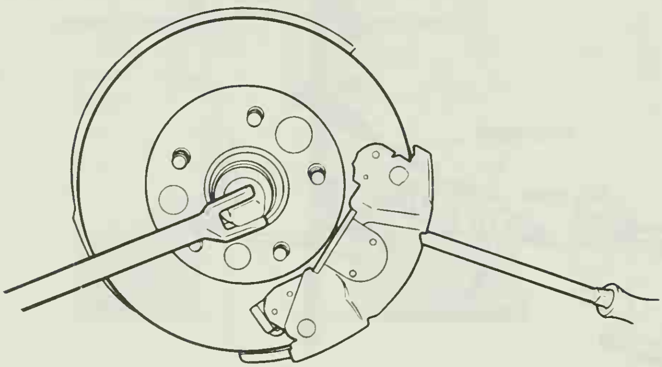


Figure 13-11. The rotor is held from turning as the hub nut is tightened. (Chevrolet Motor Division of General Motors Corporation)

JOB COMPETENCY 13-5 OVERHAUL OR LUBRICATE A FRONT-DRIVE AXLE FLEXIBLE JOINT

The inboard or outboard joint on a front-drive axle is serviced after removing the axle. Remove the axle assembly as described previously. The axle joint must be disassembled to replace or lubricate the component parts. An exploded view of an inboard joint is shown in Figure 13-12.

To remove the joint from the axle, use side cutters to cut off the seal retaining clamp. Use a **brass drift** and hammer to tap evenly around the seal retainer to remove it from the joint as shown in Figure 13-13. The race retaining snap ring can then be removed with snap ring pliers. With the snap ring removed, the joint can be separated from the axle shaft.

A screwdriver may be used to remove the ball retaining ring. The cage and inner race assembly are removed from the outer race as

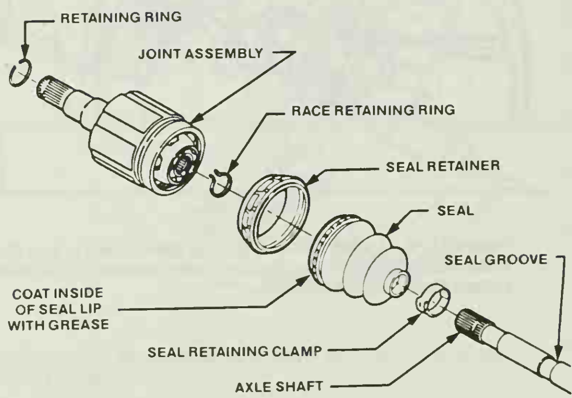


Figure 13-12. Parts of the inboard joint. (Chevrolet Motor Division of General Motors Corporation)

shown in Figure 13-14. Wash the parts in clean solvent and allow to dry. Inspect the balls and outer and inner race for wear. Replace any parts that show evidence of wear.

Lubricate and reassemble the outer and inner race. Repack the joint with the recommended type of grease. Push the reassembled joint back into position on the axle. Replace the race retaining snap ring. Install a new seal retainer, seal, and seal retaining clamp. The seal retainer may be pushed into position using an arbor press as shown in Figure 13-15. The axle may then be reinstalled as described previously.

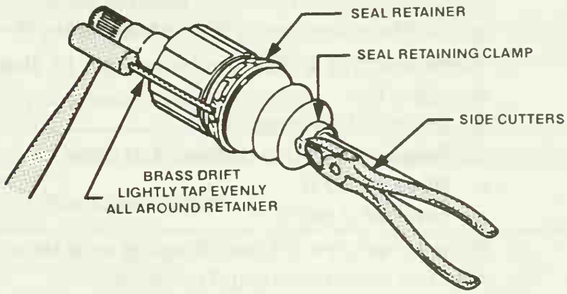


Figure 13-13. Removing the clamp and retainer. (Chevrolet Motor Division of General Motors Corporation)

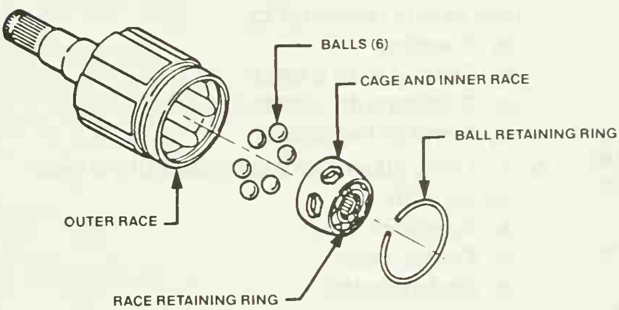


Figure 13-14. The joint is disassembled after removing the ball retaining ring. (Chevrolet Motor Division of General Motors Corporation)

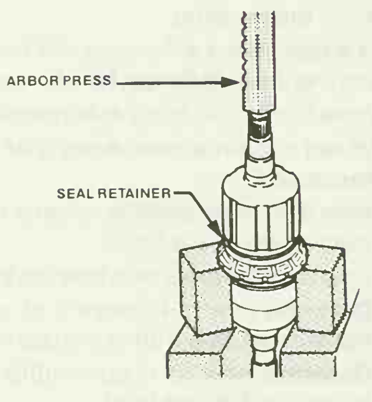


Figure 13-15. New seal retainer is replaced using the arbor press. (Chevrolet Motor Division of General Motors Corporation)

NEW TERMS

Axle end play The in and out movement of the axle shaft when it is installed in the housing.

Axle shims Shims placed between the axle housing and the outer axle bearing retainer used to adjust the axle end play.

Brass drift A tool made from soft brass, used to drive on a machined part.

JOB COMPETENCY TEST

1. What are two conditions which indicate a problem with the front-drive flexible joints?
2. Describe how to remove a rear-drive axle from the housing.
3. If a rear-drive axle does not have bolts behind the axle flange, how is it removed?
4. How is a full-floating axle removed?
5. When should a rear-drive axle seal be replaced?
6. How is an inner bearing retainer removed from a rear-drive axle?
7. How is a rear-drive axle bearing installed?
8. Describe how to remove and replace a front-drive axle from a transaxle.
9. Describe how to disassemble a front-drive axle flexible joint.
10. Explain how to assemble a front-drive axle flexible joint.

CERTIFICATION PRACTICE

1. A front-drive axle flexible joint is badly worn.
   Mechanic A says the joint will cause a clunk noise.
   Mechanic B says the joint will cause a vibration.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
2. Semifloating axles are retained in the housing by:
   a. Bolts to the housing
   b. Retainers in the differential case
   c. Both a and b
   d. Neither a nor b
3. Prior to removing a semifloating axle bearing, the mechanic must remove:
   a. Axle seal
   b. Inner retainer
   c. Outer retainer
   d. None of the above
4. The inner bearing retainer on a semifloating axle is removed by:
   a. Pressing
   b. Cutting with a torch
   c. Cutting with a chisel
   d. None of the above
5. The end play of an axle assembly is measured with:
   a. Torque wrench
   b. Feeler gage
   c. Dial indicator
   d. None of the above

ANSWERS:

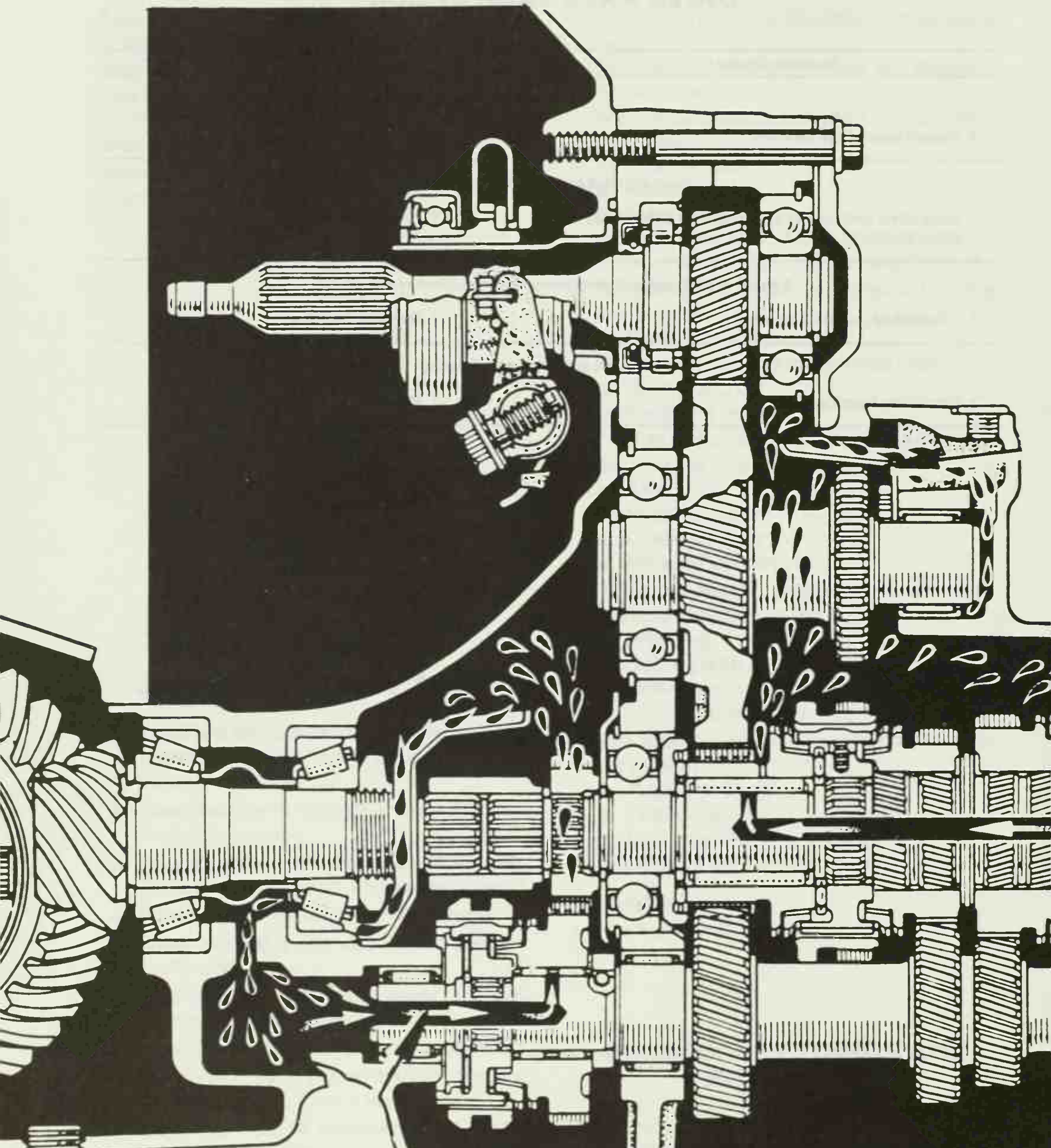
1. c, 2. c, 3. b, 4. c, 5. c

DISCUSSION TOPICS AND ACTIVITIES

1. Remove and replace a rear-drive axle assembly from a shop differential assembly.
2. Remove and replace a front-drive axle assembly from a shop transaxle assembly.

DRIVE AXLE TECH CHECK

Possible Cause	Service
Vibration	
1. Rough axle wheel bearing	1. Replace bearing
Clunk or knock on rough road operation	
1. Excessive end play of axle shafts to differential cross shaft	1. Replace axle
A knock or click approximately every two revolutions of rear wheels	
1. A brinelled rear axle bearing	1. Replace bearing
Whine that is louder during cornering	
1. Worn axle bearing	1. Replace



Unit 14
Manual Transaxle

A transaxle is a transmission and a differential combined into one housing. The transaxle is not a new concept. Vehicles with transaxles have been mass-produced since the 1930s. The down-sizing of automobiles in the late 1970s and early 1980s resulted in the development of the front-wheel-drive compact vehicle. The **front-wheel-drive** arrangement makes use of a transaxle assembly. We will present the operation of the manual transaxle in this unit.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Describe the two basic types of transaxle arrangements based on engine direction.
2. List the advantages of a transaxle system.
3. Identify the basic parts of a transaxle.
4. Describe the operation of a transaxle in each gear range.

TRANSAXLE ARRANGEMENTS

The transaxle (Figure 14-1) is one large housing that contains the clutch housing, transmission, and differential. The transaxle

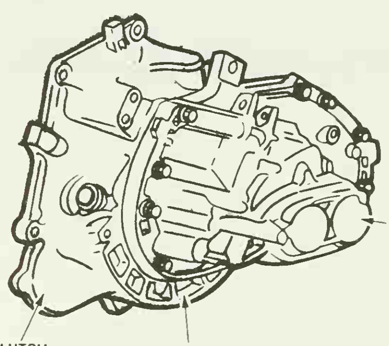


Figure 14-1. The transaxle combines the clutch housing, transmission and differential into one housing.

assembly mounts directly to the engine. The transaxle and engine may be mounted in the rear of the vehicle. This arrangement is described as a rear engine, **rear drive.** More commonly the engine and transaxle are mounted in the front of the vehicle. This arrangement is described as a front engine, front drive.

There are two basic layouts of transaxles based upon engine direction. The engine may be mounted lengthwise as shown in Figure 14-2. The front of the engine points toward the front of the vehicle. Because the drive axles must be directed out to the front wheels, the differential-and-transmission section of the transaxle is mounted below the engine.

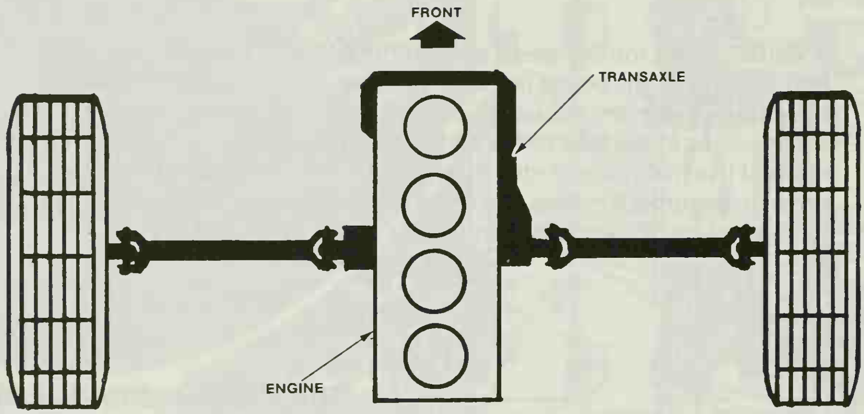


Figure 14-2. The engine may be mounted lengthwise with the transaxle below the engine.

The second basic layout uses a **transverse engine** mounting. With this arrangement the engine is mounted sideways in the engine compartment. It is possible with this design to mount the transmission and differential assembly alongside rather than below the engine as shown in Figure 14-3. This layout has the advantage of lowering the vehicle's center of gravity and making the vehicle more stable during cornering.

Regardless of the arrangement, a transaxle has many advantages over the separate transmission and engine. Combining the transmission and differential into one housing makes the car much lighter. Each pound saved in vehicle design results in more fuel efficiency.

The transaxle eliminates the drive shaft and drive shaft tunnel, and leaves more passenger space. Combining all the noise-producing elements of a vehicle in one space also helps reduce the overall noise and vibration level. The passengers get a quieter ride.

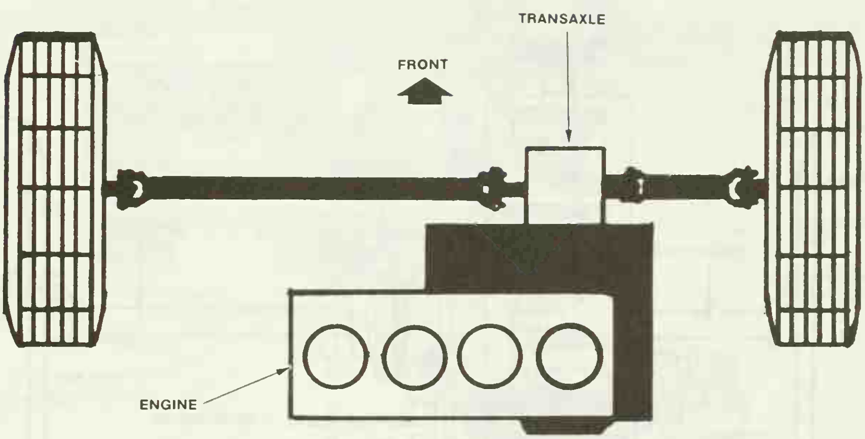


Figure 14-3. With a transverse engine mounting the transaxle assembly is mounted alongside the engine.

BASIC TRANSAXLE PARTS

The parts and operation of a transaxle are similar to those of a separate transmission and differential. The basic parts of a transaxle (with a lengthwise engine) are shown in Figure 14-4. The flywheel at the rear of the engine provides a mounting surface for the clutch pressure plate just as in a conventional drive. In this arrangement a short input shaft is engaged to the clutch disc splines. When the clutch is engaged, the engine drives this input shaft. A gear on the input shaft drives an idler gear assembly. The idler gear drives a gear on the transmission output shaft.

When the power gets to the transmission output shaft, it operates like a conventional transmission. Synchronizers control a set of **constant-mesh gears** on the transmission output shaft and countergear assembly. The driver selects which gears on these two shafts are to be locked up to provide the torque increase.

Power flows through the transmission gears and out to the differential drive pinion. The pinion is attached directly to the end of the transmission output shaft. The drive pinion turns the ring gear. The ring gear drives

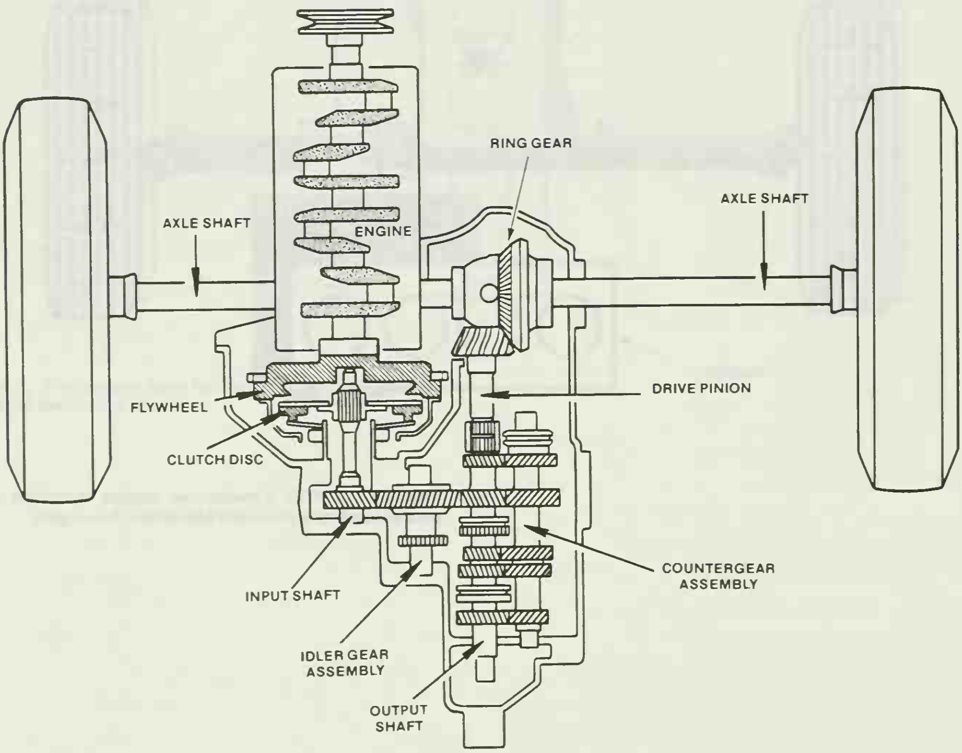


Figure 14-4. Basic parts layout of a transaxle.

the differential case and, through the differential pinions and side gears, the axle shafts and front wheels.

With a transverse engine layout, the input shaft from the clutch enters directly into the transaxle. An additional idler assembly is not required. As shown in Figure 14-5 this transaxle uses an input shaft assembly and an output shaft assembly. Several constant mesh gears and synchronizers on these shafts allow the driver to select the necessary amount of torque increase. The drive pinion is attached directly to the end of the output shaft.

The drive pinion drives the ring gear which drives the differential case. The front-wheel-drive axles are driven by the standard side gears and differential pinions inside the case.

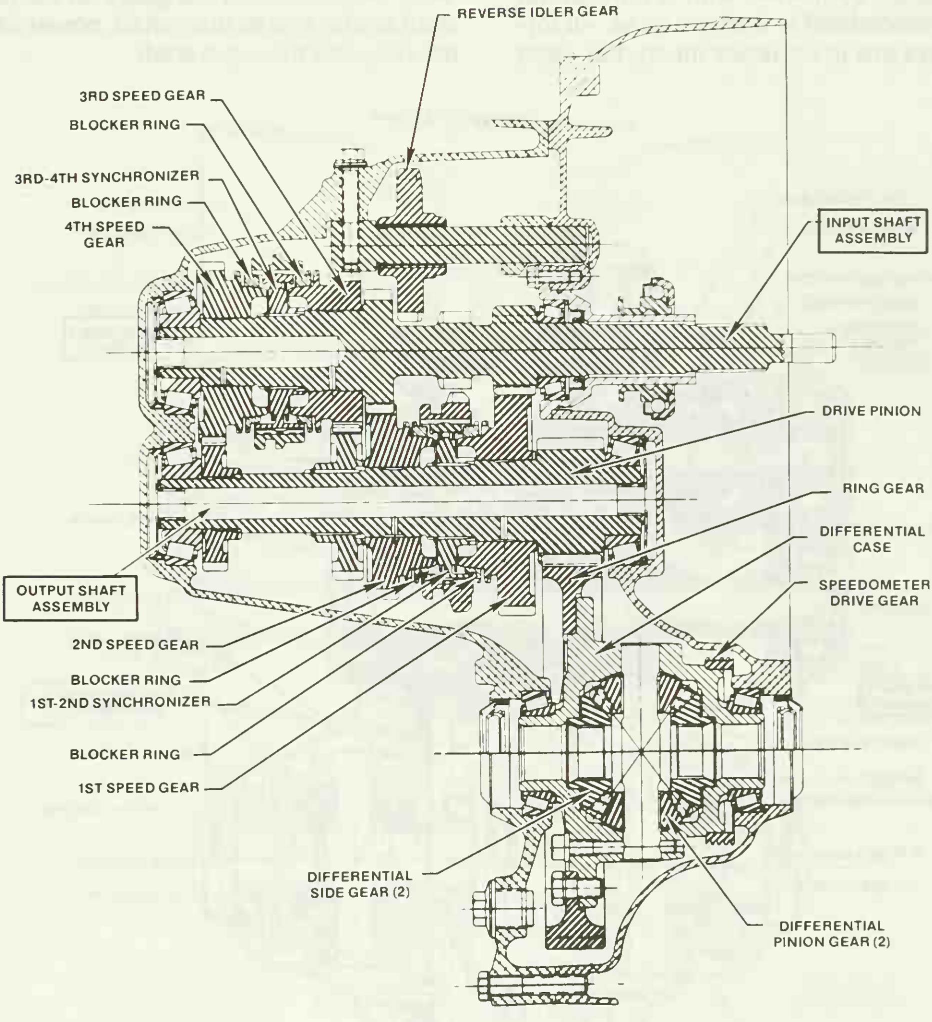


Figure 14-5. A cross-sectional view of a transaxle used with a transverse engine. (Buick Motor Division of General Motors Corporation)

TRANSAXLE OPERATION

The operation of the transaxle is essentially the same as in a conventional transmission and differential. The unit may have three, four, five, or even more forward gear reductions. In this section we will describe the operation of a four-speed transaxle assembly.

The four-speed transaxle assembly is representative of the constant-mesh design transmission, combined with a differential unit and assembled in a single case. All forward gears are in constant mesh. For ease of shifting and gear selection, synchronizers with blocker rings controlled by shifting forks are used. Reverse uses a sliding idler gear arrangement.

In neutral, with the engine running and the clutch engaged, the input gear (shaft) will turn. When the 1st-2nd and 3rd-4th synchronizers are in a neutral position, power flows into the input shaft as shown in Figure 14-6. Since none of the gears on the output shaft are locked to their shaft, power cannot flow beyond the input shaft.

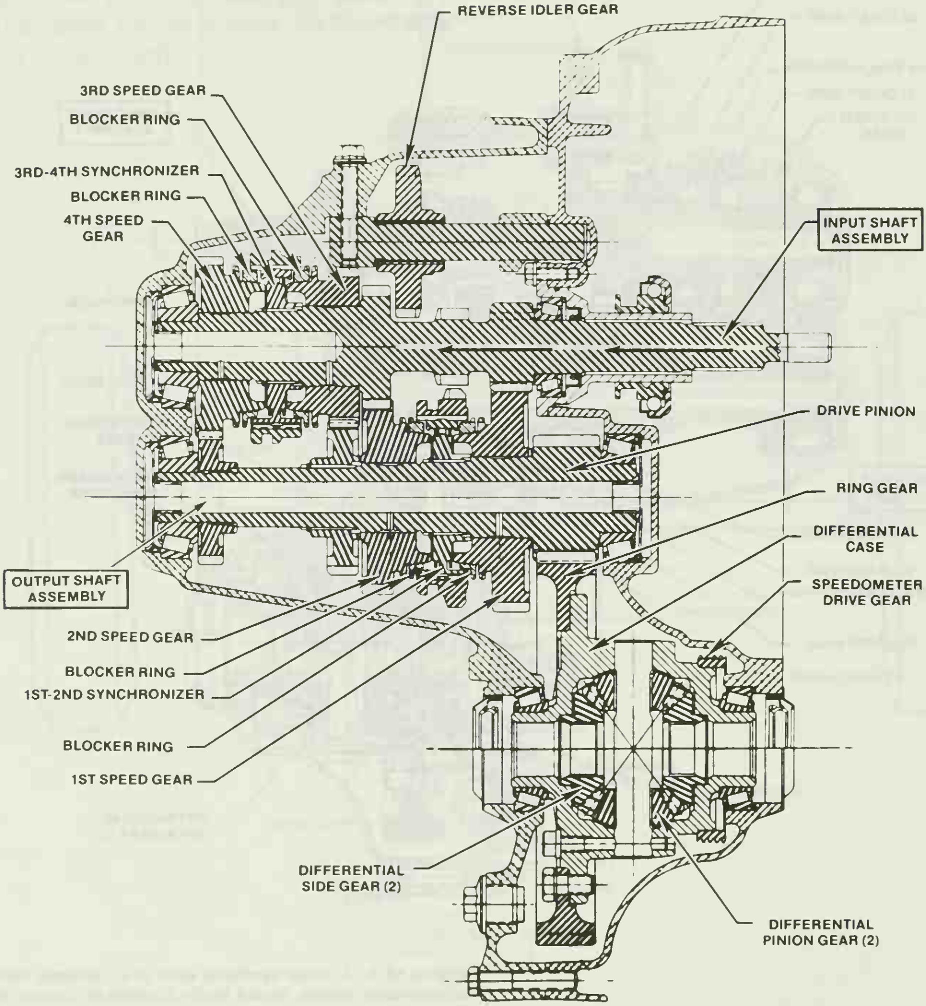


Figure 14-6. Transaxle operation in neutral. (Buick Motor Division of General Motors Corporation)

In first gear range, shown in Figure 14-7, the 3rd-4th synchronizer is in neutral, and the 1st-2nd synchronizer sleeve is moved to the right to engage the 1st speed synchronizer ring and the 1st gear. Because the 1st-2nd synchronizer hub is splined to the output gear (shaft), torque is imparted from the input gear through the 1st speed gear, the synchronizer sleeve and hub, the output gear (shaft), and into the differential assembly.

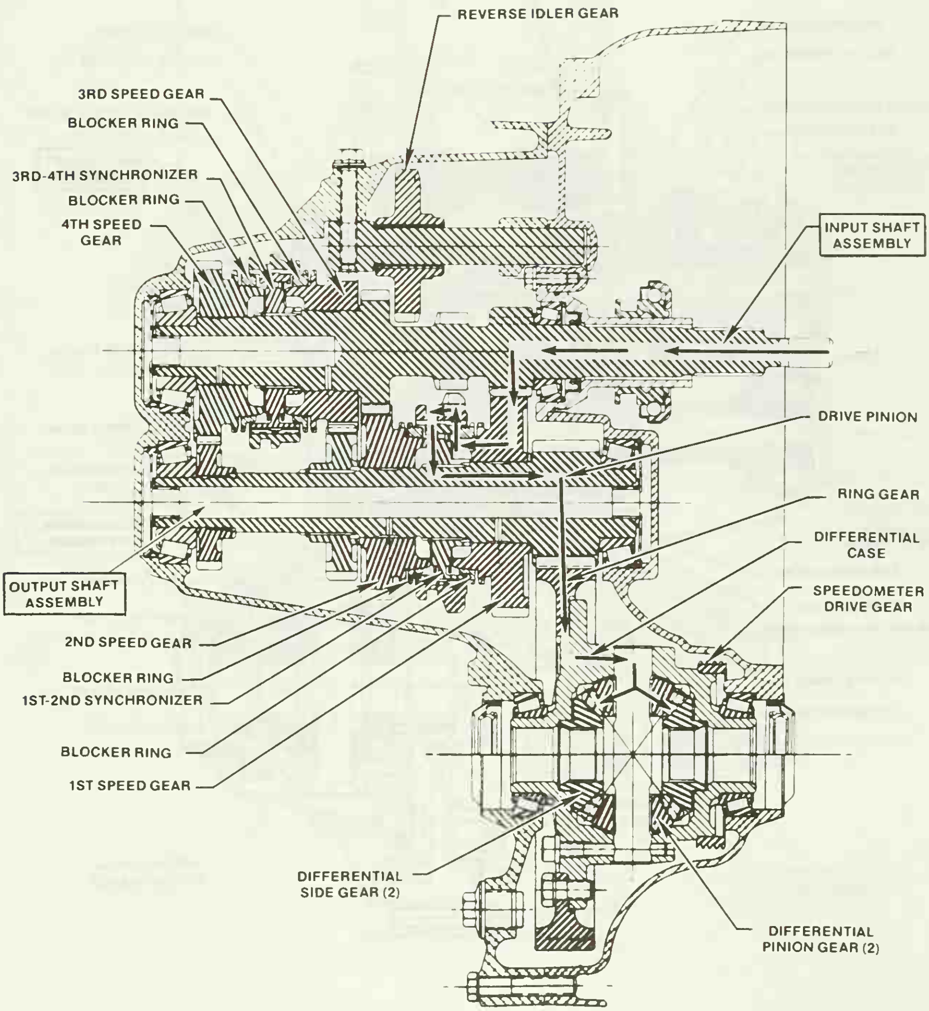


Figure 14-7. Transaxle operation in first gear. (Buick Motor Division of General Motors Corporation)

In second gear range, shown in Figure 14-8, the 3rd-4th synchronizer is in neutral and the 1st-2nd synchronizer sleeve is moved to the left to engage the 2nd speed synchronizer ring and the 2nd speed gear. With the 1st-2nd synchronizer hub splined to output gear (shaft), torque is sent from the input gear (shaft) through 2nd speed gear, the synchronizer sleeve and hub, the output gear (shaft) and into the differential assembly.

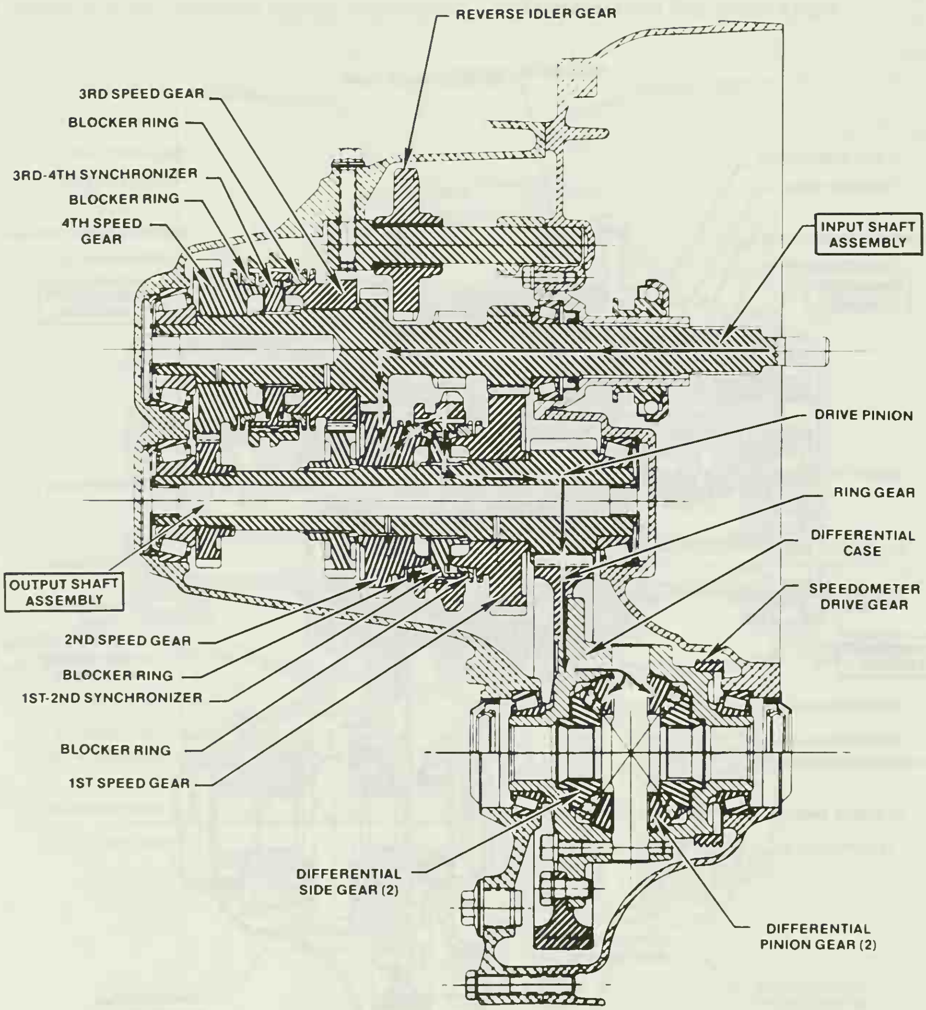


Figure 14-8. Transaxle operation in second gear. (Buick Motor Division of General Motors Corporation)

In third gear range, shown in Figure 14-9, the 1st-2nd synchronizer sleeve is moved to the neutral position, and the 3rd-4th synchronizer sleeve is moved to the right to engage the 3rd speed synchronizer ring and the 3rd speed gear. With 3rd-4th synchronizer hub splined to the input gear (shaft), torque is transferred from the input gear (shaft) through the synchronizer hub and sleeve, the 3rd gear, the output gear (shaft), and into the differential assembly.

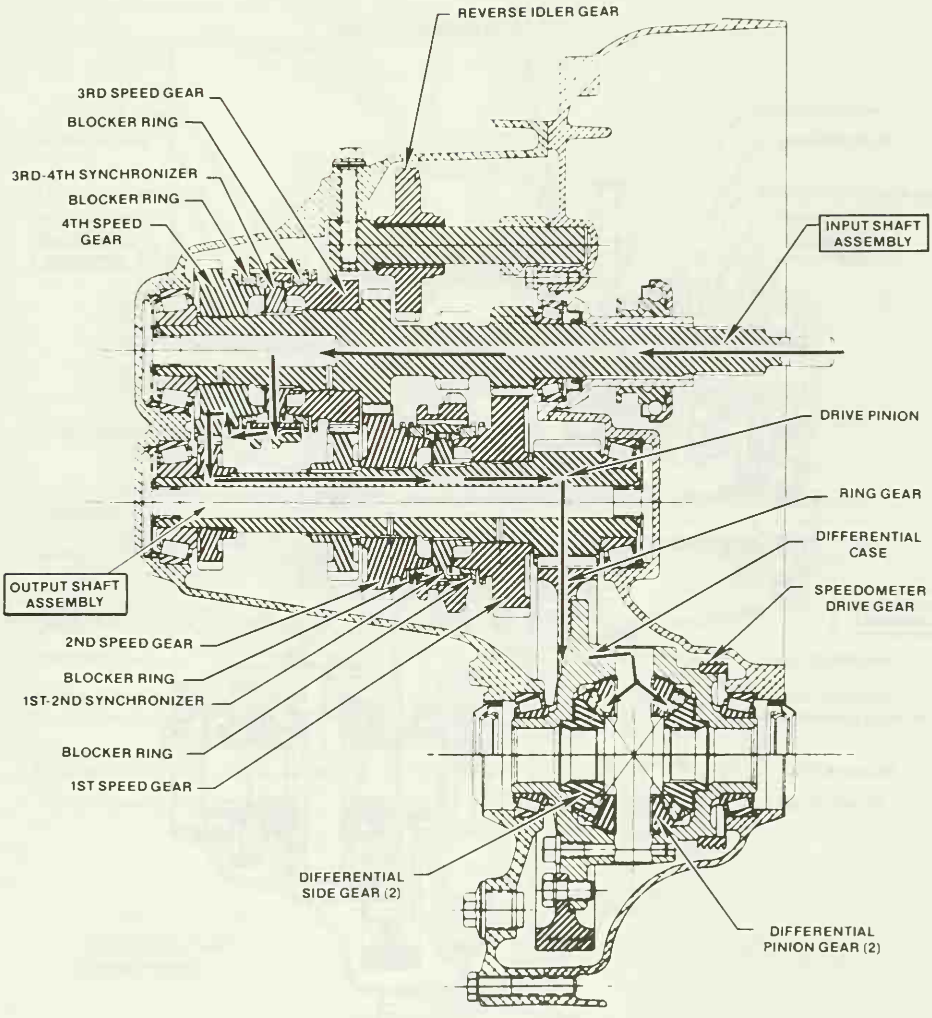


Figure 14-9. Transaxle operation in third gear. (Buick Motor Division of General Motors Corporation)

In fourth gear range, shown in Figure 14-10, the 1st-2nd synchronizer is in neutral and the 3rd-4th synchronizer sleeve is moved to the left to engage the 4th speed synchronizer ring and the 4th speed gear. With 3rd-4th synchronizer hub splined to the input gear (shaft), torque is transferred from the input gear (shaft) through the synchronizer hub and sleeve, the 4th speed gear, the output gear (shaft), and into the differential assembly.

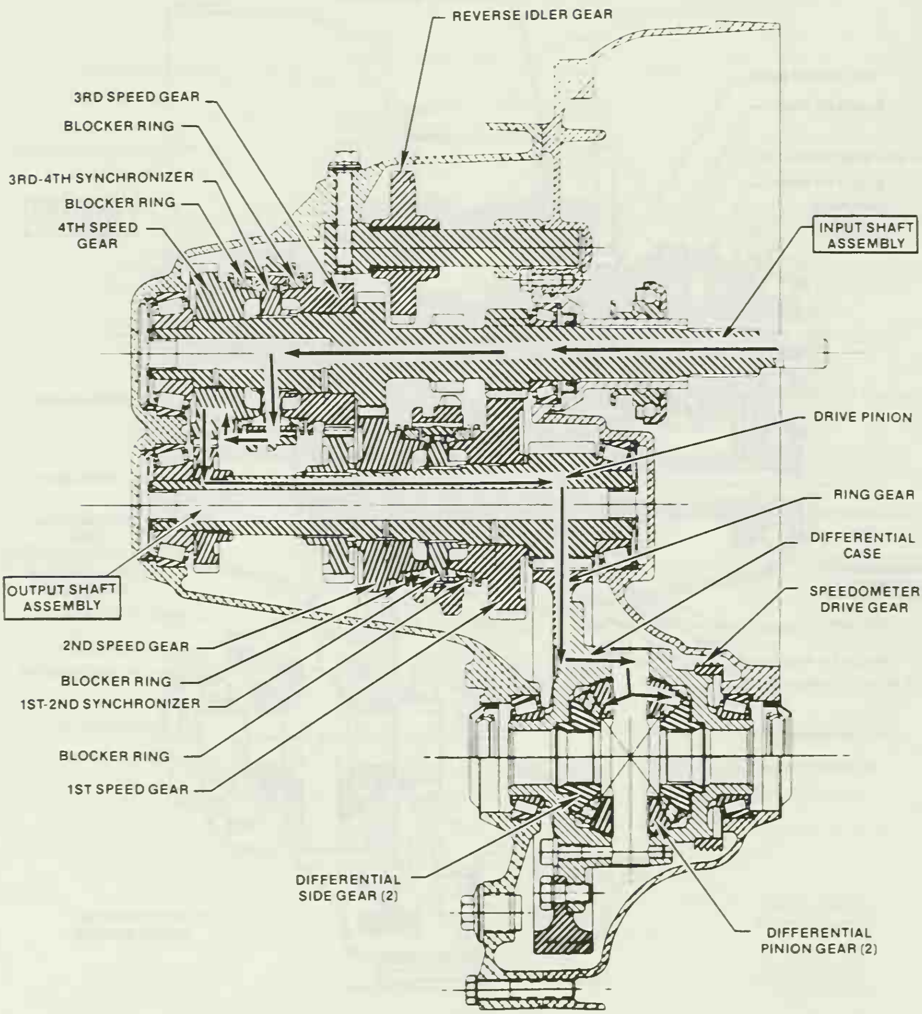


Figure 14-10. Transaxle operation in fourth gear. (Buick Motor Division of General Motors Corporation)

In reverse gear range, shown in Figure 14-11, both the 1st-2nd and 3rd-4th synchronizer sleeves are in the neutral position. The reverse idler gear is moved to engage the drive gear on the input gear (shaft) and the external teeth on the 1st-2nd synchronizer sleeve. Torque is now imparted from the input gear (shaft) through the reverse idler gear, 1st-2nd synchronizer sleeve and hub, the output gear (shaft), and into the differential assembly.

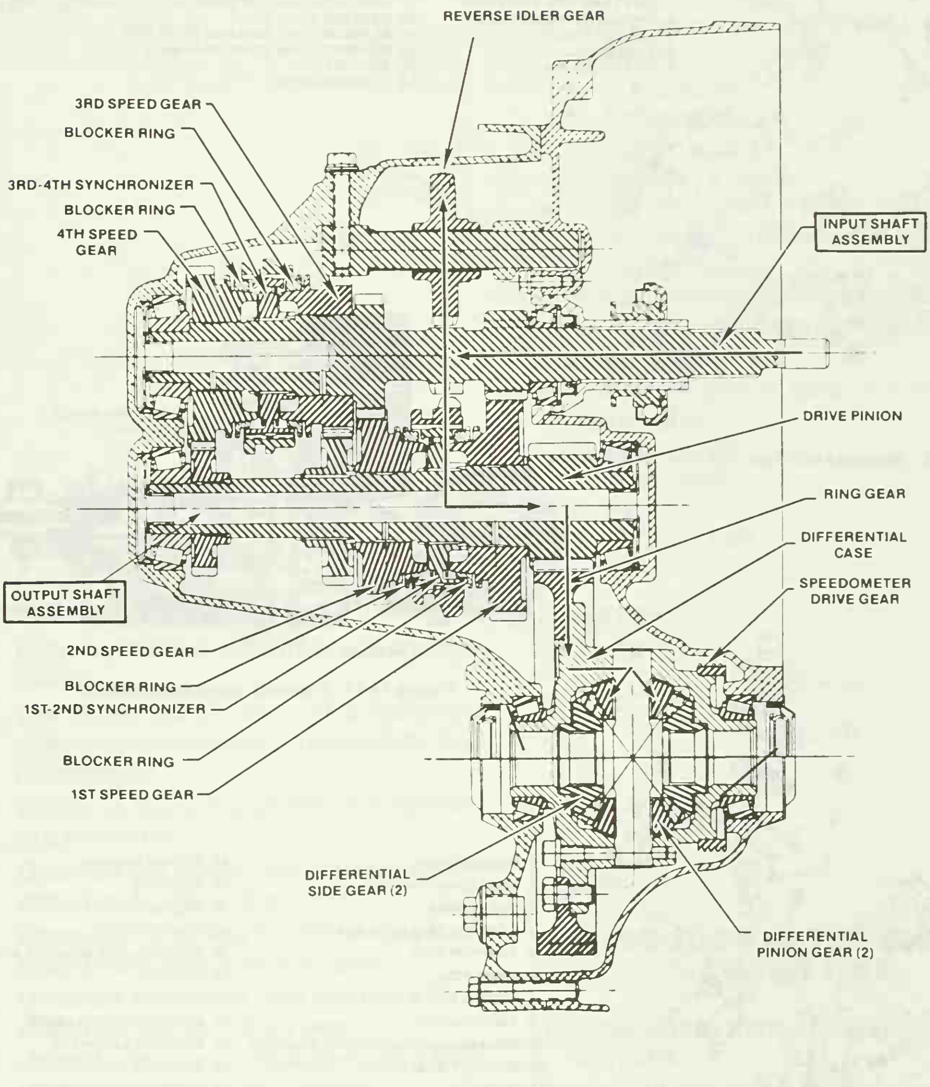
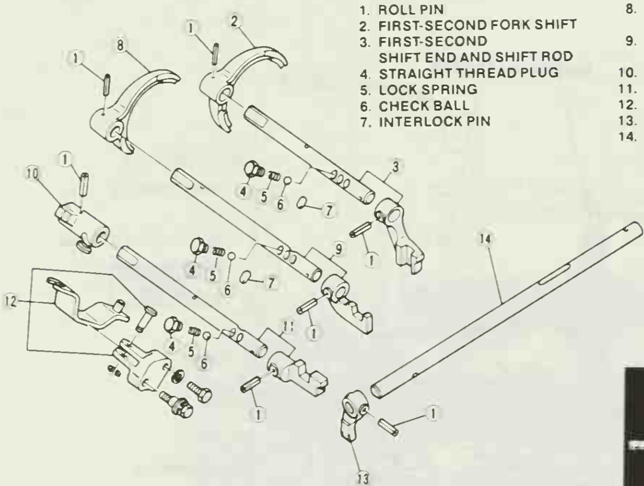


Figure 14-11. Transaxle operation in reverse gear. (Buick Motor Division of General Motors Corporation)

Shift is controlled by a system of shifting forks mounted on the shift rails. A system of shifting forks and rails for a five-speed transaxle assembly is shown in Figure 14-12. Detent plugs control the movement of the rails and shifting forks. A coupling shaft which exits from the rear of the transaxle attaches the shift mechanism to the floor shift control shown in Figure 14-13.

The transaxle assembly is lubricated by gear splash. The differential and transmission are lubricated by the same oil supply. A system of passages and oil deflectors is used to ensure that the gears located in the top of the transaxle housing get an adequate supply of lubricant. A lubrication system for a transaxle is shown in Figure 14-14.



1. ROLL PIN
2. FIRST-SECOND FORK SHIFT
3. FIRST-SECOND SHIFT END AND SHIFT ROD
4. STRAIGHT THREAD PLUG
5. LOCK SPRING
6. CHECK BALL
7. INTERLOCK PIN
8. THIRD-FOURTH FORK SHIFT
9. THIRD-FOURTH SHIFT END AND SHIFT ROD
10. REVERSE FORK SHIFT
11. REVERSE SHIFT END AND SHIFT ROD
12. REVERSE FORK LEVER ASSEMBLY
13. SHIFTER
14. CONTROL SHAFT

Figure 14-12. Transaxle shift fork and shift rail assembly.

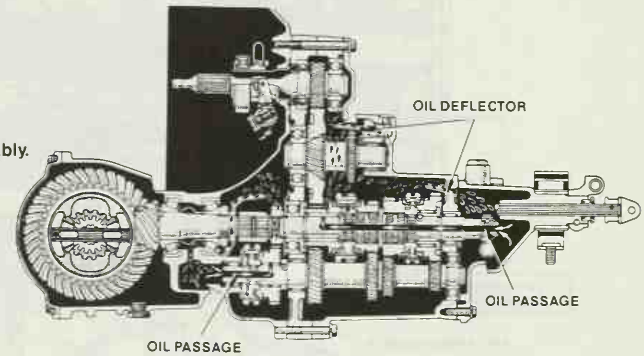
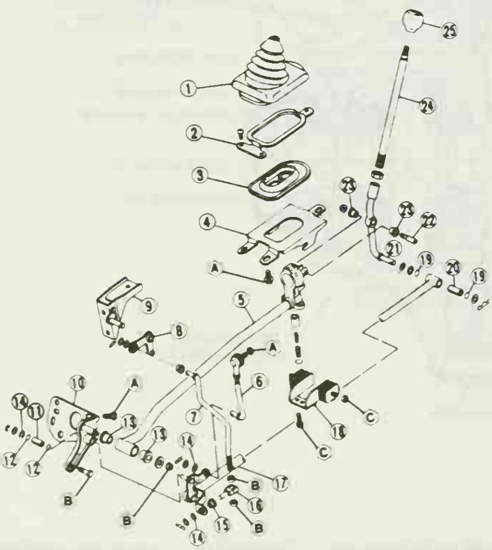


Figure 14-14. Transaxle lubrication system.



1. RUBBER BOOT
2. DUST COVER HOLDER
3. DUST COVER
4. CONTROL ROD BASE BRACKET
5. SUPPORT ROD
6. SHIFT ROD
7. SELECT ROD
8. SELECT LEVER
9. TRANSMISSION MOUNTING BRACKET
10. SUPPORT BRACKET
11. BUSHING
12. O-RING
13. BUSHING
14. SPRING WASHER
15. BUSHING
16. TRUNNION
17. CONTROL ROD
18. CONTROL ROD BRACKET MOUNTING
19. O-RING
20. BUSHING
21. LOWER CONTROL LEVER
22. CONTROL LEVER PIN
23. BUSHING
24. UPPER CONTROL LEVER
25. CONTROL KNOB

Figure 14-13. Floor shift mechanism for a transaxle. (Nissan Motor Corporation in USA)

NEW TERMS

Constant-mesh gears A gear set in which the gears are always engaged.

Front-drive transaxle A transaxle system located at the front of the vehicle and providing a drive to the front wheels.

Rear-drive transaxle A transaxle system located at the rear of the vehicle and providing a drive to the rear wheels.

Transverse engine The mounting of an engine sideways in a vehicle.

CHECK YOURSELF

1. What is a transaxle?
2. Where are transaxles mounted on the vehicle?
3. Describe the two basic transaxle arrangements.
4. List three advantages of a transaxle over a conventional transmission and differential.
5. Where is the drive pinion gear located in a transaxle?
6. Describe the power flow through a four-speed transaxle in first gear.
7. Describe the power flow through a four-speed transaxle in second gear.
8. Describe the power flow through a four-speed transaxle in third gear.
9. Describe the power flow through a four-speed transaxle in fourth gear.
10. Describe the power flow through a four-speed transaxle in reverse gear.

CERTIFICATION PRACTICE

1. A transaxle assembly includes:
   a. Clutch housing
   b. Transmission assembly
   c. Differential assembly
   d. All of the above
2. The transaxle may be arranged:
   a. Below the engine
   b. Alongside the engine
   c. Both a and b
   d. Neither a nor b
3. The engine used with a transaxle is mounted:
   a. Transverse
   b. Lengthwise
   c. Either a or b
   d. Neither a nor b
4. An advantage of a transaxle over a conventional transmission and differential is:
   a. Lighter weight
   b. Elimination of drive shaft
   c. Isolation of noise and vibration
   d. All the above
5. The drive pinion gear in a transaxle is attached to:
   a. Drive shaft
   b. Axle shaft
   c. Input shaft
   d. Output shaft

ANSWERS:

1.d, 2.c, 3.c, 4.d, 5.d

DISCUSSION TOPICS AND ACTIVITIES

1. Disassemble a shop transaxle and identify the parts.
2. Lay out the parts of a transaxle on the bench and trace the power flow in each operating range.

Unit 15
Manual Transaxle Service

The transaxle assembly is subject to the same kinds of wear as the individual transmission and differential. Most of the same service procedures described for transmissions and differentials are used in the repair of a transaxle. Like the individual transmission and differential, transaxle service involves regular periodic maintenance, diagnosis to determine the cause of a problem and service to correct the source of a problem. In this unit we will present the service procedures which are used on the typical transaxle.

Preventive Maintenance

Troubleshooting

Service

JOB COMPETENCIES TO BE DEVELOPED

When you finish reading and studying this unit, you should be able to:

15-1 Check, drain, and refill the lubricant in a transaxle.
15-2 Perform a transaxle road test and trouble diagnosis.
15-3 Adjust transaxle shifting control.
15-4 Remove a transaxle from a vehicle.
15-5 Disassemble a transaxle.
15-6 Reassemble the transaxle.
15-7 Install the transaxle in a vehicle.

JOB COMPETENCY 15-1 CHECK, DRAIN, AND REFILL THE LUBRICANT IN A TRANSAXLE

The lubricant level in a transaxle should be checked periodically and adjusted as necessary. Raise the vehicle on a hoist, making sure it is level. Locate and remove the transaxle fill plug (Figure 15-1). The level of the fluid should be at or near the bottom of the filler plug opening. If the lubricant is low, add the correct amount and type of fluid. Some manufacturers use automatic transmission fluid in their standard transmission transaxle. Others use hypoid gear lubricant. Always check the manufacturer's service manual for the correct fluid type.

Some manufacturers recommend regular intervals for transaxle drain and refill. Other manufacturers specify that the unit should be drained only if the fluid becomes contaminated.

To drain the fluid, raise the vehicle on a hoist making sure it is level. Remove the drain plug at the bottom of the transaxle (Figure 15-1). Allow the fluid to drain into a pan. Replace the drain plug and tighten it to specifications with a torque wrench. Refill the unit through the filler plug with the correct type and amount of fluid.

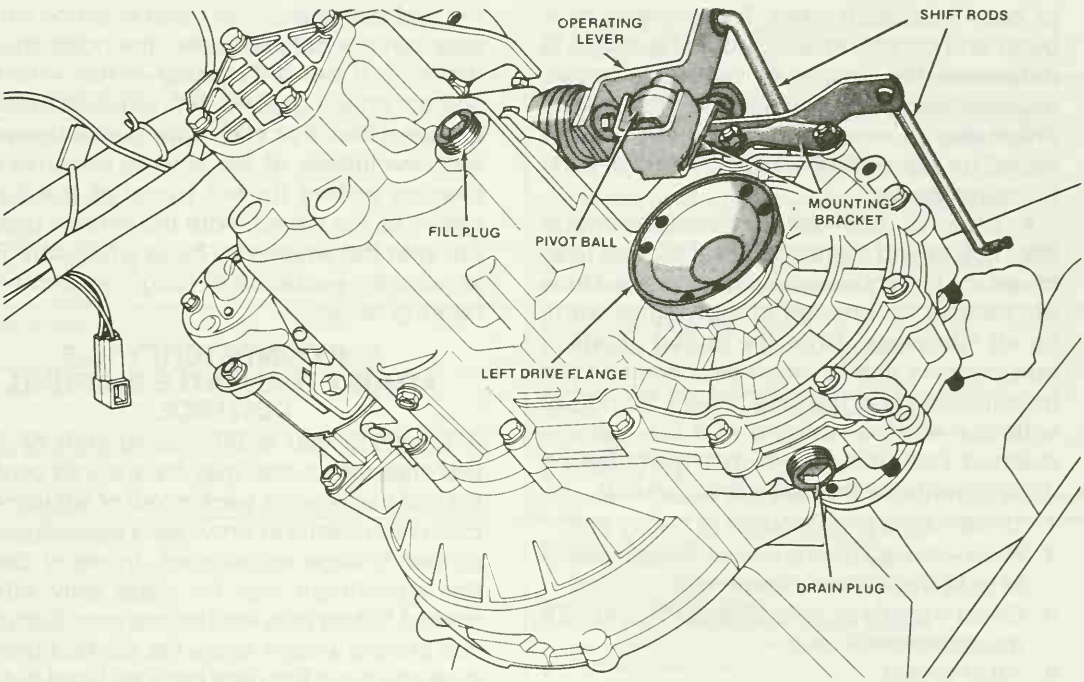


Figure 15-1. Location of the drain and fill plugs on a transaxle. (Chrysler Corporation)

JOB COMPETENCY 15-2
PERFORM A TRANSAXLE ROAD TEST AND TROUBLE DIAGNOSIS

Before trying to repair the clutch, transaxle, or related linkages for any reason other than an obvious failure, identify the problem and probable cause. A large percentage of clutch and manual transaxle problems show up as shifting difficulties such as high shift effort, gear clash and grinding, or blockout. When any of these problems occurs, follow a careful troubleshooting procedure.

Diagnosis of drive train noises may seem baffling because many noises which seem to be coming from the transaxle may actually be originating from other sources, such as the tires, road surfaces, wheel bearings, the engine, or the exhaust system. These noises may vary by vehicle size, type, and amount of body insulation used. Therefore, a thorough and careful check should be made to determine the source of the noise before disassembling the transaxle. Noise which originates in other places cannot be corrected by adjustment or replacement of parts in the transaxle.

In order to road-test for transaxle operation, first select a smooth, level asphalt road to reduce tire and resonant body noise. Drive the vehicle far enough to thoroughly warm up all lubricants. Note the speed at which noise occurs and in which gear position the transmission is at the time. Check for noises with the engine running and the vehicle stopped. Determine in which of the following drive conditions the noise is occurring:

1. Drive—light acceleration or heavy pull
2. Float—maintaining constant vehicle speed at light throttle on a level road
3. Coast—partly or fully closed throttle with transmission in gear
4. All of above

After road-testing the vehicle, refer to a troubleshooting guide in the manufacturer's service manual for conditions and probable causes. A troubleshooting guide for a transaxle is shown in Figure 15-2.

Bad bearings generally produce a rough "growl" or "grating" sound, rather than the "whine" which is typical of gear noise. Before diagnosing a bearing problem, clean the cone assembly thoroughly in solvent and allow to dry completely. When you remove a suspected bearing, carefully inspect it to determine the cause of the problem and whether any related parts have been damaged. If the bearing has become magnetized, you cannot remove the metal particles from inside the cage until the bearing is demagnetized.

Since the differential side bearings are preloaded, the noise should not go away or diminish appreciably when the differential is run with the wheels off the ground. Noise in the differential side bearing area can easily be confused with wheel bearing noise. Inspect and replace bearings, as required during service.

A rough bearing produces a vibration or growl which continues with the vehicle coasting and transmission in neutral. Since wheel bearings are not preloaded, the noise should diminish if the differential is run with the wheels off the ground. A brinnelled bearing causes a knock or click approximately every two revolutions of the wheels because the bearing rollers do not travel at the same speed as the wheel. With the wheels jacked up, spin the wheels by hand while listening at hubs for evidence of rough or brinnelled bearing noise.

JOB COMPETENCY 15-3
ADJUST TRANSAXLE SHIFTING CONTROL

A transaxle that is difficult to shift or one that slips out of gear may have a shift control linkage that is worn, bent, or out of adjustment. Each manufacturer provides a procedure for proper linkage adjustment. In many cases this adjustment may be made only with a special fixture provided by the manufacturer. You should always know the correct procedure and have the right tools on hand before starting this job.

Some transaxles have shift rods and others use shift cables. The adjustment procedure is essentially the same for both types. The transaxle must be shifted into the gear specified for checking the linkage. Remove the rubber boot from the shift coupler assembly on the transaxle.

CONDITION	PROBABLE CAUSE
Noise is the same in drive or coast.	a. Road Noise. b. Tire noise. c. Front wheel bearing noise. d. Incorrect drive axle angle. (Standing Height)
Noise changes on a different type of road.	a. Road noise. b. Tire noise.
Noise tone lowers as car speed is lowered.	Tire noise.
Noise is produced with engine running vehicle stopped and/or driving.	a. Engine noise. b. Transaxle noise. c. Exhaust noise.
A knock at low speeds.	a. Worn drive axle joints. b. Worn side gear hub counterbore.
Noise most pronounced on turns.	Differential gear noise.
Clunk on acceleration or deceleration.	a. Loose engine mounts. b. Worn differential pinion shaft in case or side gear hub counterbore in case worn oversize. c. Worn or damaged drive axle inboard joints.
Clicking noise in turns.	Worn or damaged outboard joint.
Vibration	a. Rough wheel bearing. b. Damaged drive axle shaft. c. Out of round tires. d. Tire unbalance. e. Worn joint in drive axle shaft. f. Incorrect drive axle angle.
Noisy in Neutral with Engine Running	Damaged input gear bearings.
Noisy in First Only Noisy in Second Only	a. Damaged or worn first-speed constant mesh gears. b. Damaged or worn 1-2 synchronizer. a. Damaged or worn second-speed constant mesh gears. b. Damaged or worn 1-2 synchronizer.
Noisy in Third Only	a. Damaged or worn third-speed constant mesh gears. b. Damaged or worn 3-4 synchronizer.
Noisy in High Gear	a. Damaged 3-4 synchronizer. b. Damaged 4th speed gear or output gear.
Noisy in Reverse Only	a. Worn or damaged reverse idler gear or idler bushing. b. Worn or damaged 1-2 synchronizer sleeve.
Noisy in All Gears	a. Insufficient lubricant. b. Damaged or worn bearings. c. Worn or damaged input gear (shaft) and/or output gear (shaft.)
Slips out of Gear	a. Worn or improperly adjusted linkage. b. Transmission loose on engine housing. c. Shift linkage does not work freely; binds. d. Bent or damaged cables. e. Input gear bearing retainer broken or loose. f. Dirt between clutch cover and engine housing. g. Stiff shift lever seal.
Leaks Lubricant	a. Axle shaft seals b. Excessive amount of lubricant in transmission. c. Loose or broken input gear (shaft) bearing retainer. d. Input gear bearing retainer "O" ring and/or lip seal damaged. e. Lack of sealant between case and clutch cover or loose clutch cover. f. Shift lever seal leaks.

Figure 15-2. A transaxle diagnosis chart is used to determine the cause and what to look for when the unit is disassembled for service. (Chevrolet Motor Division of General Motors Corporation)

The procedure described below is specified for a typical cable-operated shift mechanism. A rod unit is adjusted in a similar way. Install two pins of the correct diameter into the alignment holes in the control assembly. This ensures that the assembly is held in 1st gear position as shown in Figure 15-3. Attach the two shift cables to the control assembly using the studs and pin retainers. Cables must be routed correctly and must operate freely.

Place the transaxle in 1st gear by pushing the rail selector shaft inward (down) just to the point of feeling the resistance of the inhibitor spring. Then rotate the shift lever fully counterclockwise. Install the stud with cable A attached into the slotted area in the shift lever. Install the stud with cable B attached into the slotted area of the select lever, while lightly pulling on the select lever to remove lash. Remove two pins at control assembly. Road-test the vehicle and check for a good

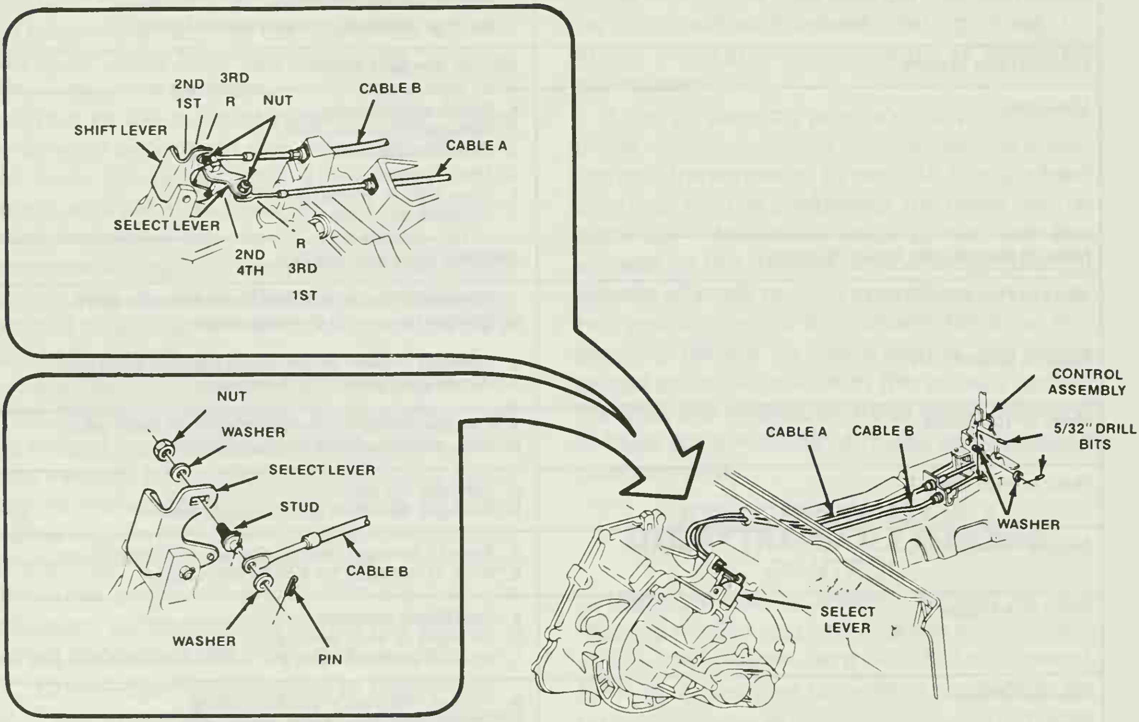


Figure 15-3. Shift cable adjustment procedure. (Chevrolet Motor Division of General Motors Corporation)

neutral gate feel during shifting. It may be necessary to fine-tune the adjustment after road-testing.

JOB COMPETENCY 15-4 REMOVE A TRANSAXLE FROM A VEHICLE

There are several general methods to remove and replace a transaxle. One is to remove the engine with the transaxle attached out of the top of the engine compartment. This is the procedure used on a few imported subcompacts. On rear engine vehicles the engine is usually removed first, and then the transaxle is removed from under the vehicle. The most common procedure and the one we will describe here is to support the engine and leave it in place. The transaxle is then separated from the engine and removed from under the vehicle.

Many front-drive vehicles have the transaxle mounted on a removable subframe. This subframe shown in Figure 15-4 is often called a **cradle.** The cradle is removed by unbolting it from the body. It must be removed to remove the transaxle.

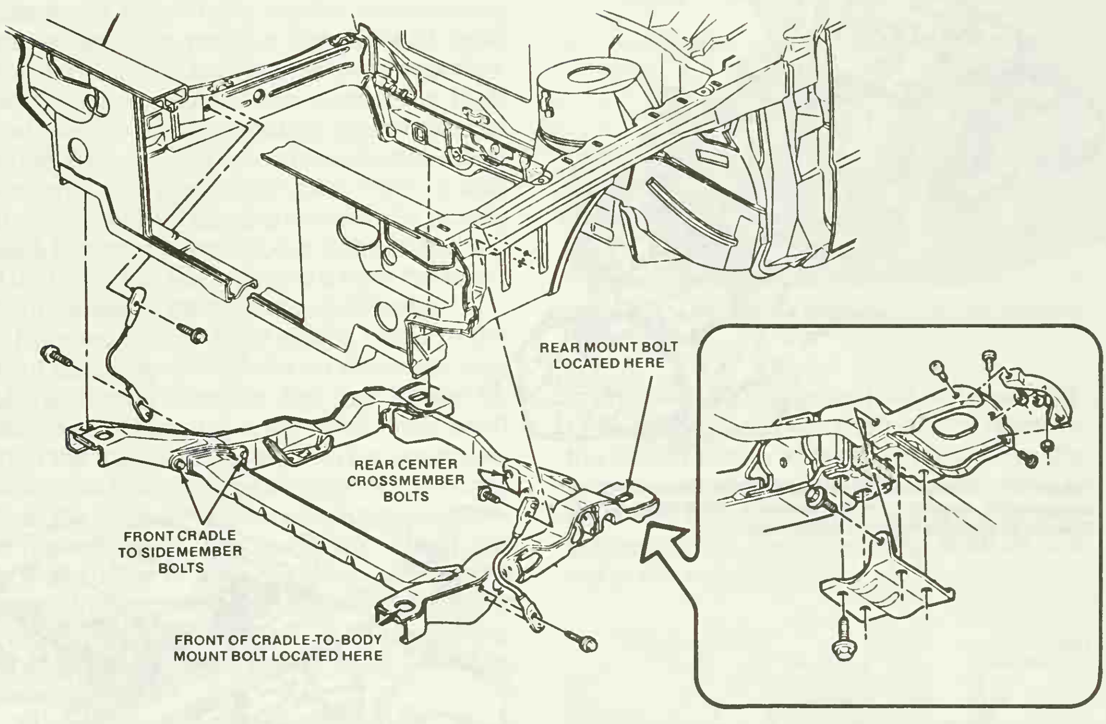


Figure 15-4. A removable subframe called a cradle supports the transaxle on many vehicles. (Buick Motor Division of General Motors Corporation)

To remove the transaxle, first disconnect the battery negative cable to prevent any accidental engine cranking. Disconnect the battery ground cable from the transaxle case and attach it to the upper radiator hose with wire or tape. If the transaxle has two transaxle strut bracket bolts at the transaxle on the side of the engine compartment, remove them. Remove top engine-to-transaxle bolts and the ones at the rear of the car near the cowl. The transaxle-to-engine bolts are shown in Figure 15-5.

Loosen the engine-to-transaxle bolt near the starter, at the front of the car, but do not remove it. Disconnect the speedometer cable at the transaxle. For cruise-control cars, remove the transaxle speedometer cable at the cruise-control transducer. Remove the retaining clip and washer from the transaxle shifting linkage at the transaxle case. Install an engine-holding fixture as shown in Figure 15-6. Attach a fixture hook to the engine lift ring and raise the engine enough to take the pressure off the motor mounts.

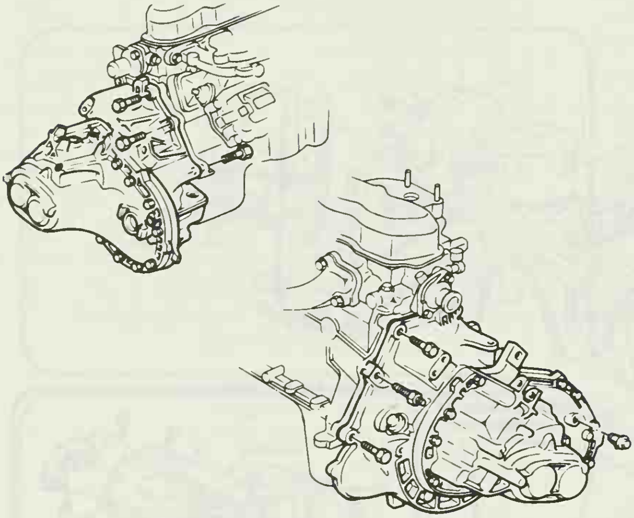


Figure 15-5. The transaxle-to-engine bolts are removed to separate the engine from the transaxle. (Chevrolet Motor Division of General Motors Corporation)

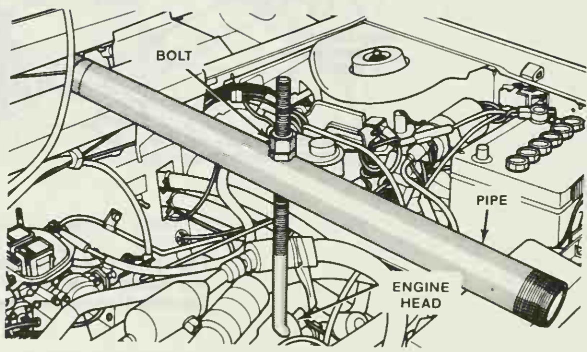


Figure 15-6. An engine support fixture is used to support the engine when the transaxle is removed. (Chrysler Corporation)

Safety Note: ***The engine support fixture must be located in the center of the cowl, and fasteners must be properly torqued before supporting the engine. The fixture is not intended to support the entire weight of the engine and transaxle. Bodily injury could result with improper use of the support fixture.***

Unlock the steering column and raise the car. Remove the drain plug and drain fluid from the transaxle case. Remove the nuts attaching the stabilizer bar to the lower control arm on the driver side. Remove the bolts that attach the retaining plate holding the driver side stabilizer bar to cradle. Loosen the bolts holding the stabilizer bracket on the passenger side of the cradle. If necessary, disconnect and remove the exhaust pipe. Pull the stabilizer bar down on the driver side. Remove the nuts and disconnect the front and rear transaxle mounts at the cradle. Remove the rear center crossmember bolts. Remove the passenger side front cradle attaching bolts. Nuts are reached by pulling back the splash shield next to the frame rail. If there is a top bolt, remove it from the lower front transaxle damper shock absorber.

Remove the left front wheel. Remove the front cradle-to-body bolts on the driver side of the cradle. Remove the rear cradle-to-body bolts. Pull the driver side drive shaft from the transaxle assembly. The passenger side drive shaft may be simply disconnected from the case. When the transaxle assembly is removed, you can swing the passenger side shaft out of the way. Swing the partial cradle to the driver side and wire it securely outboard to the fender well. Remove the flywheel and starter shield bolts. Remove the shields.

Support the transaxle on a floor jack. Make sure all transaxle-to-engine bolts are removed. Slide the transaxle assembly to the left and rear of the car until the mainshaft clears the clutch. Lower the transaxle and remove it from under the vehicle. Thoroughly clean the exterior of the unit.

JOB COMPETENCY 15-5 DISASSEMBLE A TRANSAXLE

Locate and follow the service manual disassembly procedure for the transaxle being serviced. The following procedures are typical of most transaxles.

Mount the transaxle on a holding stand or place it on a bench. If there is a clutch push rod, remove it from the center of the input shaft. Remove the dust plug from one of the drive flanges. Use snap ring pliers to remove the snap ring and cone washer from the drive flange as shown in Figure 15-7. A puller may then be used to pull the flange from its splines. Repeat this procedure on the other flange.

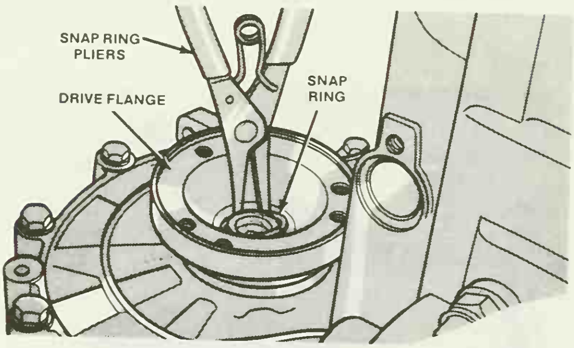


Figure 15-7. Removing the drive flange snap ring. (Chrysler Corporation)

Pry the drive flange seal out of its housing. Remove the selector shaft cover. Remove the detent spring assembly and remove the selector shaft boot seal. Push out the selector shaft and selector shaft assembly as shown in Figure 15-8. Pry the selector shaft oil seal out of the housing.

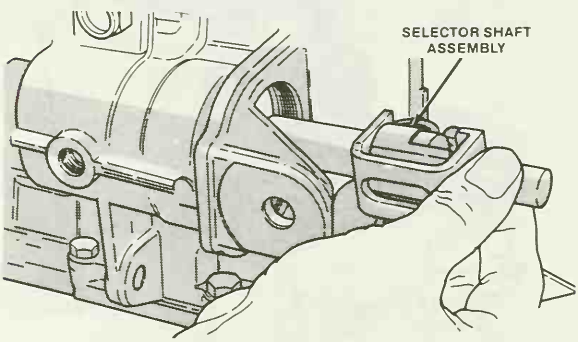


Figure 15-8. Removing the selector shaft assembly. (Chrysler Corporation)

Remove the release bearing end cover bolts and remove the cover. While removing, hold the clutch release lever in an upward position to avoid loading the end cover and damaging the case threads. Remove the release bearing and sleeve from under the cover. Using two screwdrivers, push the retaining ring off the torque shaft. Remove the return spring and release lever as shown in Figure 15-9. Pry the torque shaft oil seal out of the housing.

Remove the mainshaft bearing retainer nuts and washer. Remove the reverse idler shaft set screw and remove the back-up light switch from the sides of the case. Pull the transmission case up and off the gear assembly.

Remove the reverse shifting fork supports by removing the fork's retaining bolts. Pull the reverse shifting fork out of the case. Remove the mainshaft assembly and pinion shaft 4th speed gear as shown in Figure 15-10. Use a puller as shown in Figure 15-11 to remove the mainshaft bearing and mainshaft 4th speed gear. Lift off the 3rd-4th synchronizer and 3rd speed gear and bearing assembly from the mainshaft.

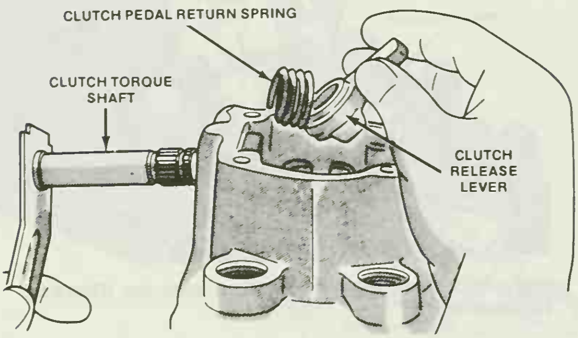


Figure 15-9. Removing the clutch release lever assembly. (Chrysler Corporation)

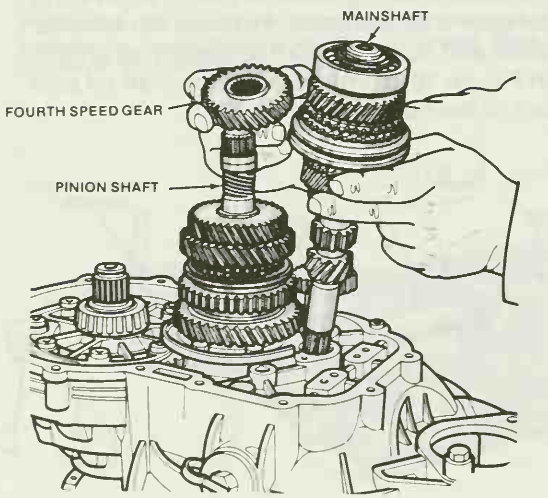


Figure 15-10. Removing the mainshaft assembly. (Chrysler Corporation)

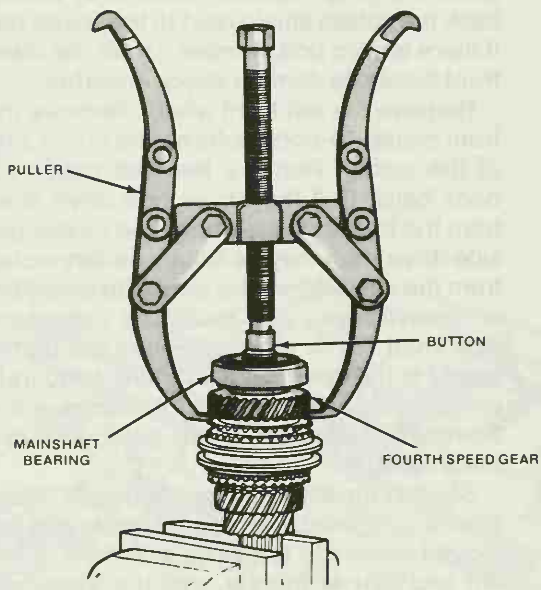


Figure 15-11. A puller is used to remove the mainshaft bearing and mainshaft fourth-speed gear. (Chrysler Corporation)

The shifting fork assembly is removed by removing the retaining clips from the shift rail with a screwdriver. The shifting fork assembly may then be removed as shown in Figure 15-12. With the shifting fork assembly removed, lift the 3rd-4th synchronizer off the shaft as an assembly. The remaining parts are removed from the mainshaft. A disassembled view of the mainshaft is shown in Figure 15-13.

Scribe index marks on the synchronizer assembly so that it may be reassembled in the same position. Inspect the synchronizer sleeve for excessive spline chipping or wear. Place synchronizer springs with the tab located inside the strut cavity. Note the staggered location of spring tabs. Inspect the synchronizer rings for cracks or thread wear. Synchronizers are serviced as an assembly. Synchronizer parts should not be interchanged.

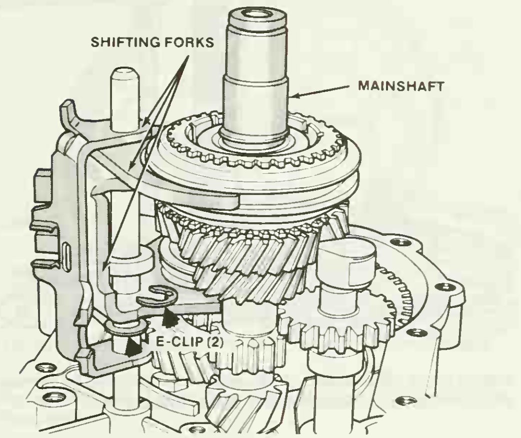


Figure 15-12. Removing the shifting fork assembly. (Chrysler Corporation)

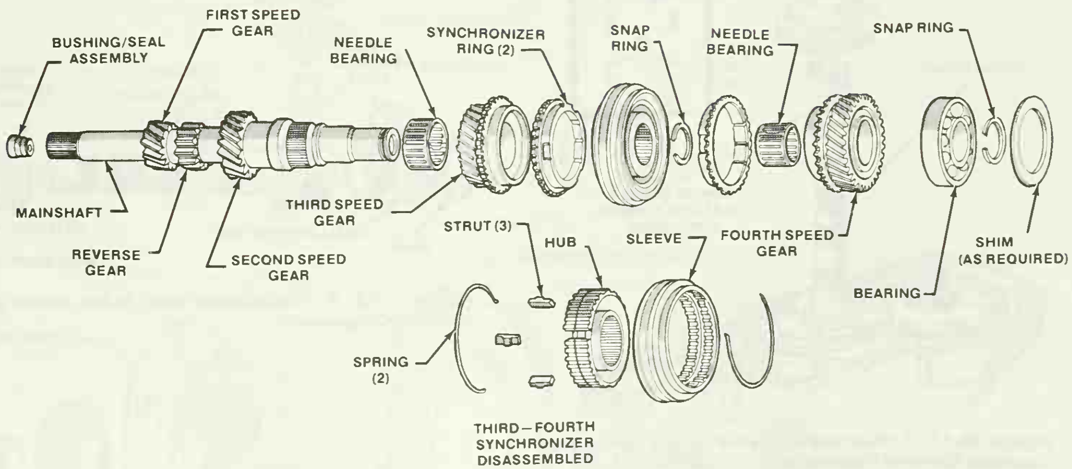


Figure 15-13. A disassembled view of a mainshaft assembly. (Chrysler Corporation)

Remove the snap ring that retains the 3rd speed gear on the pinion shaft. Remove the 2nd speed gear and needle bearing. Use a pry bar to remove the reverse idler shaft. Use a puller to remove the 1st-2nd synchronizer assembly off the pinion shaft. The 1st speed gear and 1st speed gear needle bearing may be lifted off the pinion shaft. Scribe and check the 1st-2nd synchronizer assembly just as the 3rd-4th unit. A disassembled view of the pinion shaft assembly is shown in Figure 15-14.

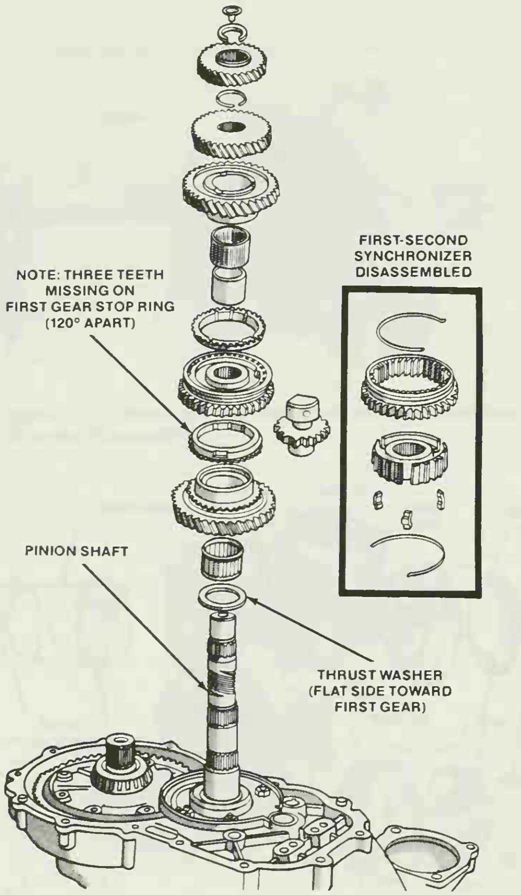


Figure 15-14. A disassembled view of the pinion shaft assembly. (Chrysler Corporation)

The pinion shaft is held in the case with a retainer plate. Remove the bolts holding the retainer plate (Figure 15-15) and lift off the plate. Then lift off the 1st gear thrust washer. The pinion shaft may then be lifted out of the case. A disassembled view of the pinion shaft is shown in Figure 15-16. Remove the mainshaft seal by prying it out of the case.

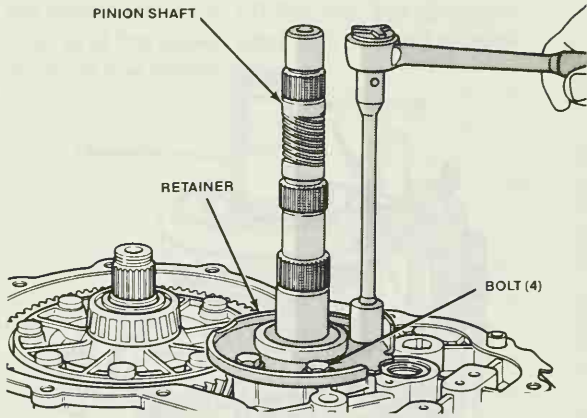


Figure 15-15. The pinion shaft retainer is removed by removing the retainer plate bolts. (Chrysler Corporation)

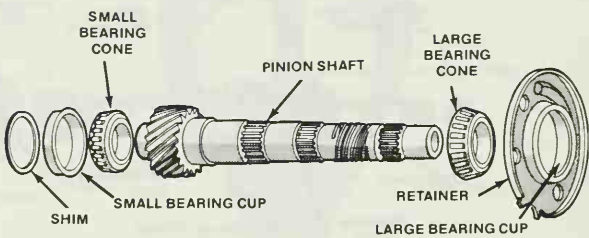


Figure 15-16. A disassembled view of the pinion shaft. (Chrysler Corporation)

With the pinion shaft removed, the differential case may be lifted out of the housing. Hold the axle shafts in place with **circlips** which can be removed with two screwdrivers as shown in Figure 15-17. Inspect the bearings and, if necessary, remove them from the case with a puller. Remove bearing cups in the transaxle housing with a bearing driver.

With the circlips removed, you can remove the axle shafts. The axle side gears can be removed through the opening in the case. Remove the snap ring on the pinion gear shaft and drive out the pinion shaft with a brass drift. A disassembled view of the differential is shown in Figure 15-18. The ring gear may be retained with rivets. To replace

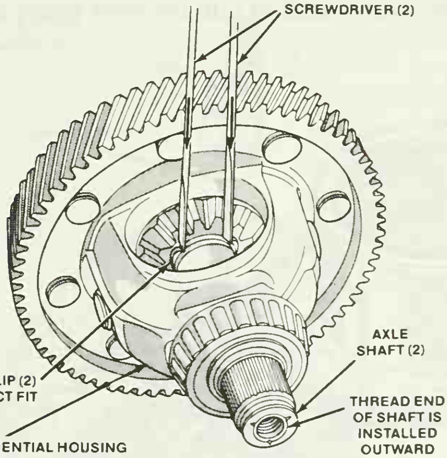


Figure 15-17. Removing the axle retaining circlips. (Chrysler Corporation)

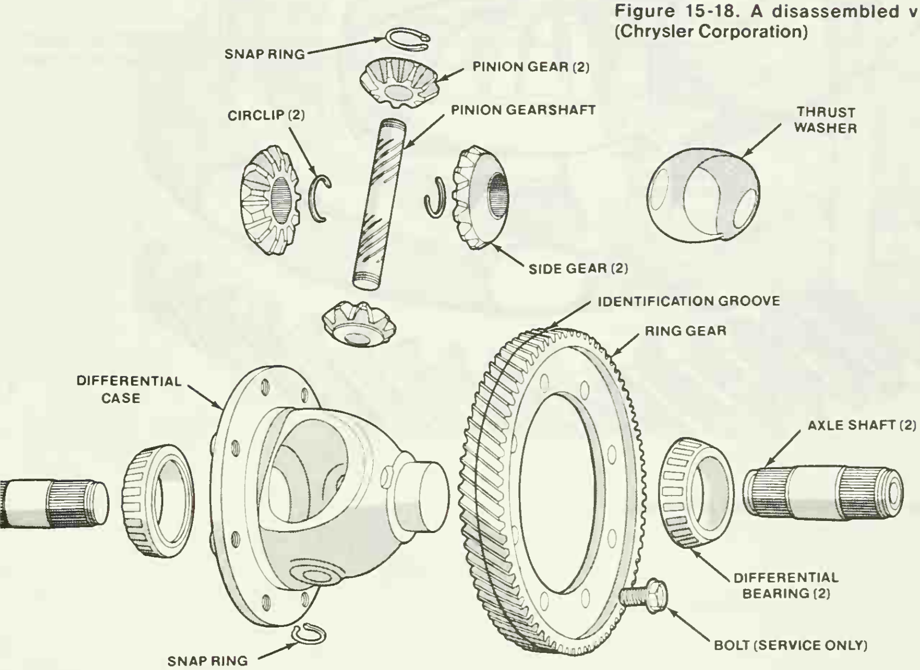


Figure 15-18. A disassembled view of the differential. (Chrysler Corporation)

the gear, drill out the rivets and install the new gear with bolts.

Wash the transaxle transmission and differential components in solvent and allow to dry on a clean shop towel. Oil all the bearings, shafts, and gears after cleaning to prevent rust. Inspect the parts for wear as previously described under separate transmission and differential assemblies.

JOB COMPETENCY 15-6 REASSEMBLE THE TRANSAXLE

Begin the case reassembly by installing the pinion gears and pinion shaft assembly along with the thrust washer. Use a brass drift to drive the shaft into the case. Install the pinion gearshaft snap rings. Install the differential side gears through the case opening as shown in Figure 15-19. The axle shafts are then installed into the side gears and a

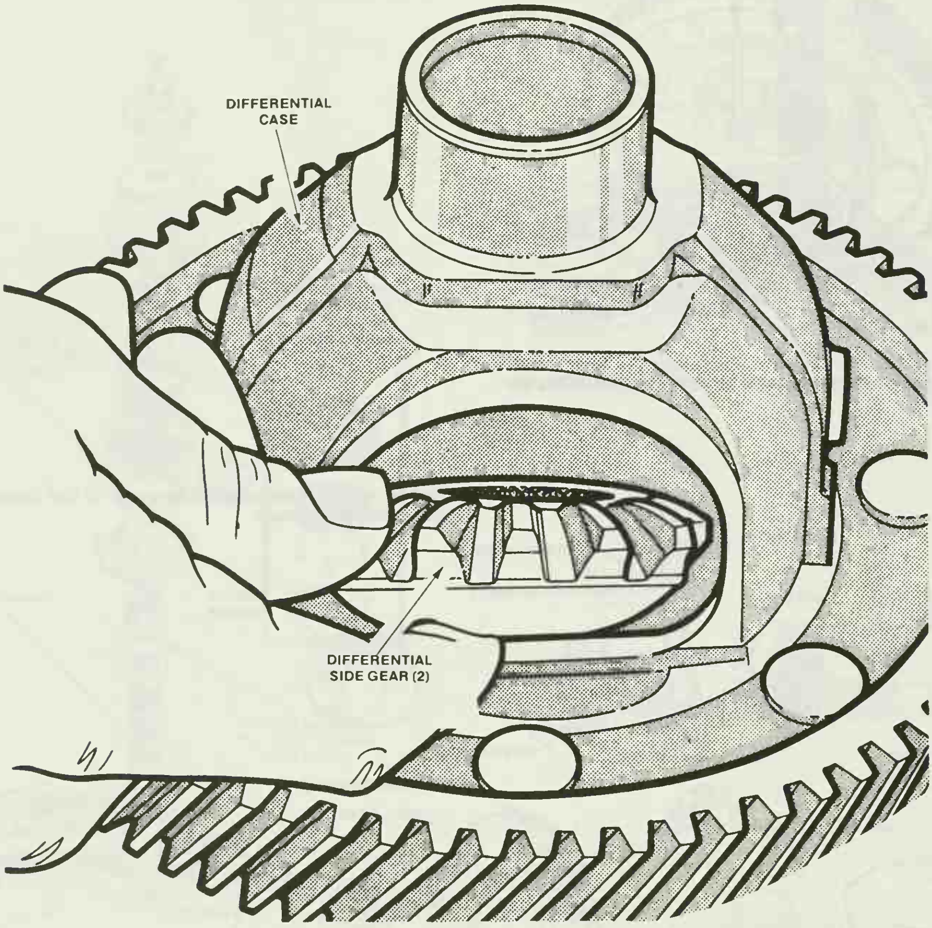


Figure 15-19. Installing the differential side gears in the case. (Chrysler Corporation)

circlip of the correct thickness installed as shown in Figure 15-20. Use the thickest possible circlip to remove all the axle shaft end play.

You must adjust the preload to the differential case bearings if you replace the transmission housing, clutch housing, differential case or differential bearings. Preloading is achieved with shims under the bearing cups. Follow the specific manufacturer's procedure for determining shim thickness.

To reassemble the case, begin by installing a new mainshaft seal in the case. Use a seal driver and hammer to install the new seal as shown in Figure 15-21.

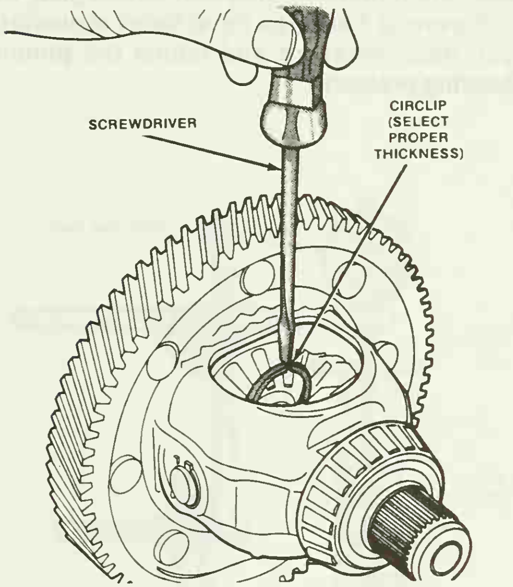


Figure 15-20. The thickest possible circlip is used to remove axle shaft end play. (Chrysler Corporation)

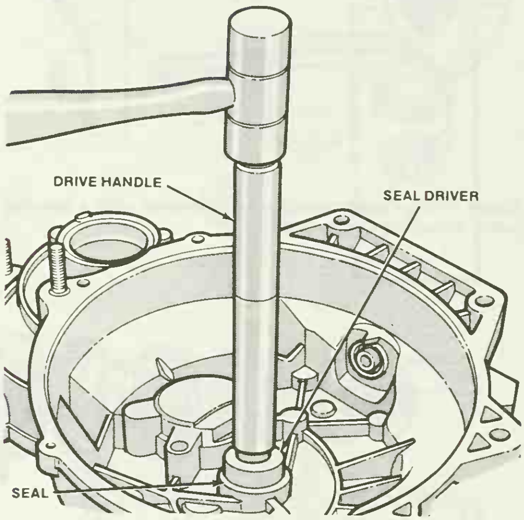


Figure 15-21. Installing a new mainshaft oil seal in the case. (Chrysler Corporation)

If either pinion shaft bearing needs replacement, pull off the bearing with a bearing puller as shown in Figure 15-22. A new bearing may then be pressed or driven on the shaft with a bearing driver. Remove the pinion bearing cups only if the bearing is to be replaced. Pull the cups out of the case with a bearing puller and replace with a bearing driver. If necessary, replace the needle bearing for the pinion shaft by driving it into and out of the case.

The case is now ready for reassembly. Remember to coat each component with gear lubricant as it is installed in the case. Use an exploded view of the transaxle assembly like the one shown in Figure 15-23 as an aid during reassembly.

Place the pinion shaft in the case. Replace the retaining plate over the pinion shaft and tighten the bolts to the specified torque. If the clutch housing, ring and pinion gear, or differential bearings have been replaced, you must measure and adjust the **pinion bearing preload.**

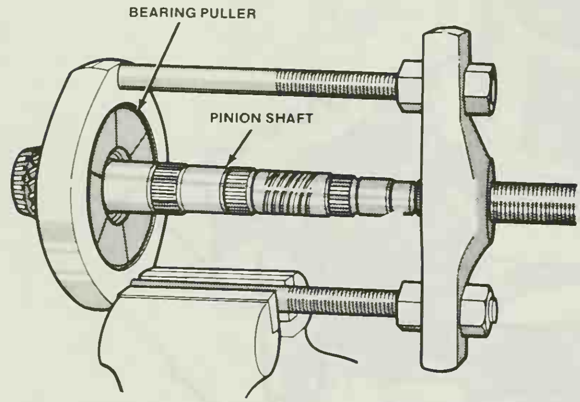


Figure 15-22. Pinion bearings are removed with a bearing puller. (Chrysler Corporation)

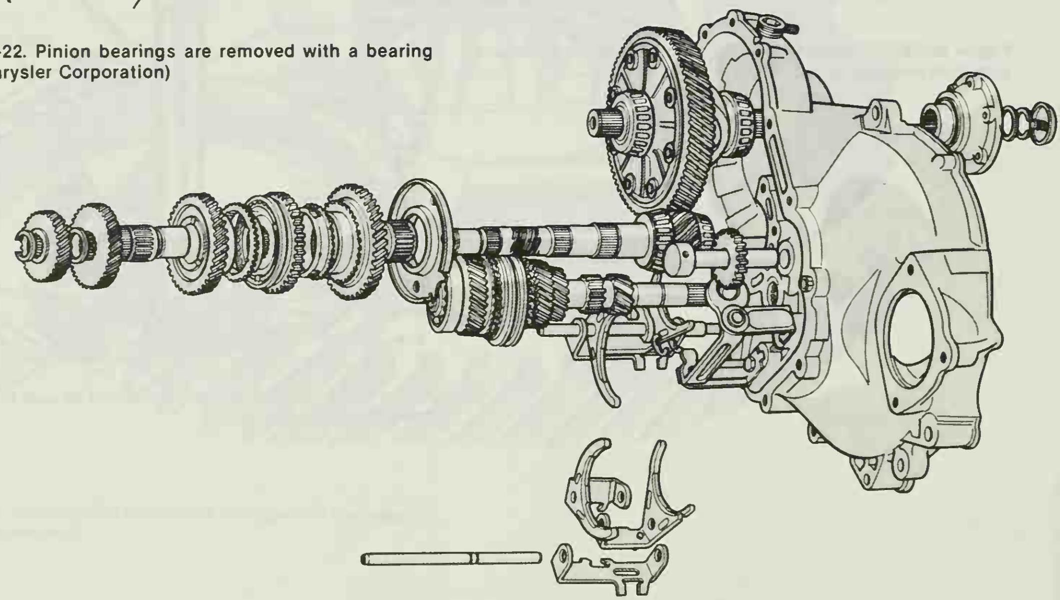


Figure 15-23. An exploded view of the transaxle helps in reassembly. (Chrysler Corporation)

Pinion bearing preload is the amount the pinion shaft can move up and down. The preload is measured with a dial indicator on the end of the pinion shaft as shown in Figure 15-24. Adjust the preload by using shims of different thicknesses under the pinion shaft. Follow the specific manufacturer's recommendations for shim procedure and preload measurement.

With the pinion shaft in position and preloaded properly assemble the parts over the shaft (Figure 15-25). Make sure the synchronizer hub and sleeve are aligned using the scribe marks made during disassembly. Install the 1st speed gear and synchronizer ring. Install the 1st-2nd synchronizer. Use the correct size driver to drive the 2nd gear bearing race into position. Install the reverse

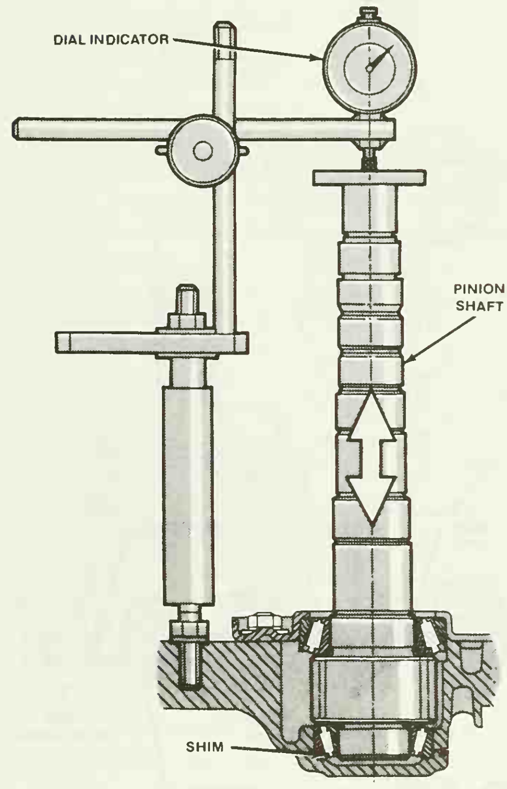


Figure 15-24. Pinion bearing preload is measured with a dial indicator and corrected with shims under the pinion shaft. (Chrysler Corporation)

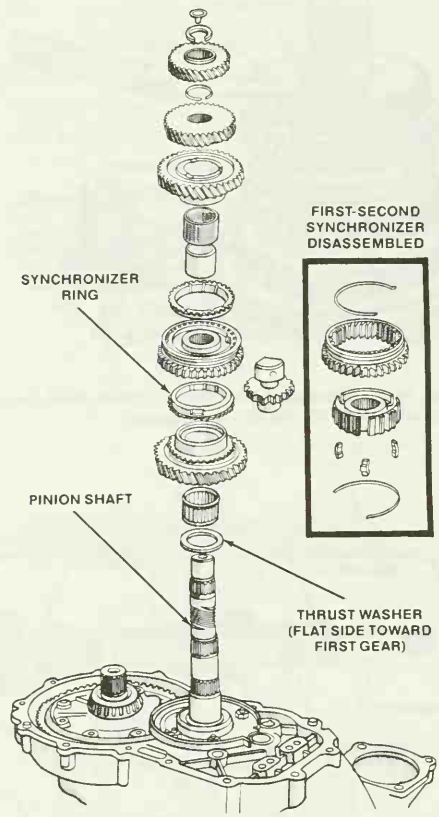


Figure 15-25. With the pinion shaft assembled, the parts are replaced on the shaft. (Chrysler Corporation)

idler gear shaft making sure the shaft is properly aligned. Install the needle bearing and 2nd speed gear. Place the 3rd speed gear in position over its splines. The snap ring that retains the 3rd gear is selective. Check the end play by measuring the space between the snap ring and 3rd gear with a feeler gage as shown in Figure 15-26. If end play is not correct, install a thicker or thinner snap ring.

The mainshaft assembly (Figure 15-27) is partially assembled on the bench. Place the needle bearing and 3rd speed gear on the shaft. Assemble the 3rd-4th synchronizer assembly using the scribe marks made during

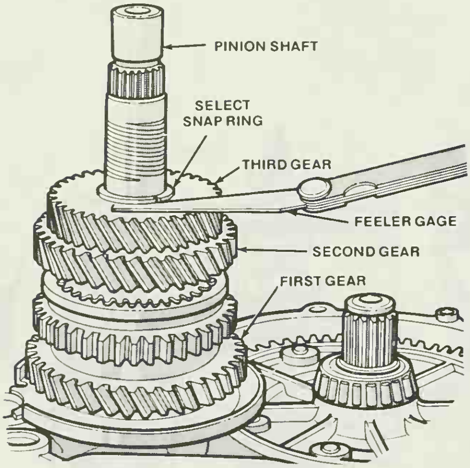


Figure 15-26. Measuring end play between third gear and select snap ring. (Chrysler Corporation)

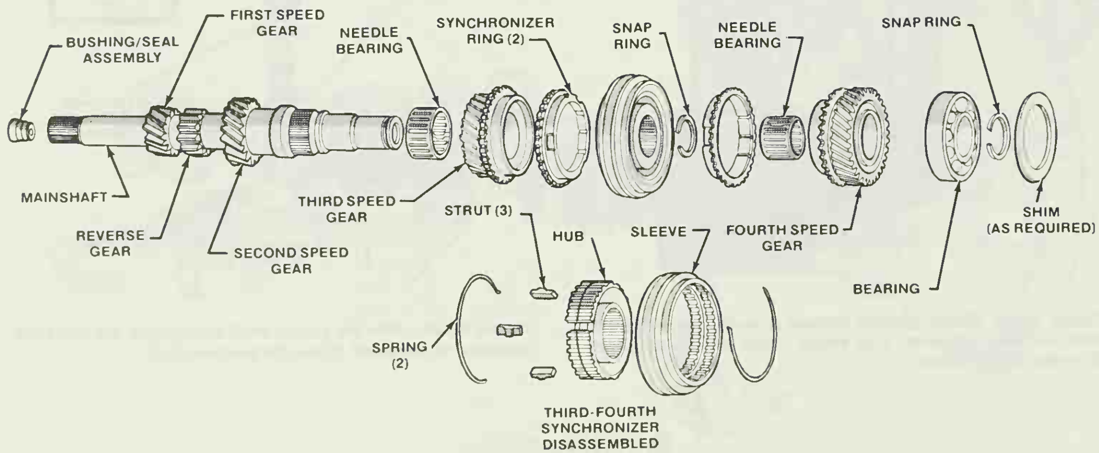


Figure 15-27. Parts which are assembled on the mainshaft. (Chrysler Corporation)

disassembly. Then place the synchronizer on the mainshaft. Install the mainshaft assembly into the case as shown in Figure 15-28.

With the mainshaft installed, the 4th speed gear mainshaft needle bearing is placed on the shaft. Place the 4th speed gear in position over the bearing. Install the snap ring to hold the components in place. After assembly, measure the **mainshaft end play.** A special dial indicator assembly is mounted on the end of the mainshaft as shown in Figure 15-29. Move the mainshaft up and down and record the end play. Unless the case, clutch housing, or mainshaft has been replaced, adjustment will not be necessary. Adjust end play to specifications with shims on the end of the mainshaft between the mainshaft ball bearing and transmission housing.

Reassemble the shifting fork and rail assembly and install the assembly into the

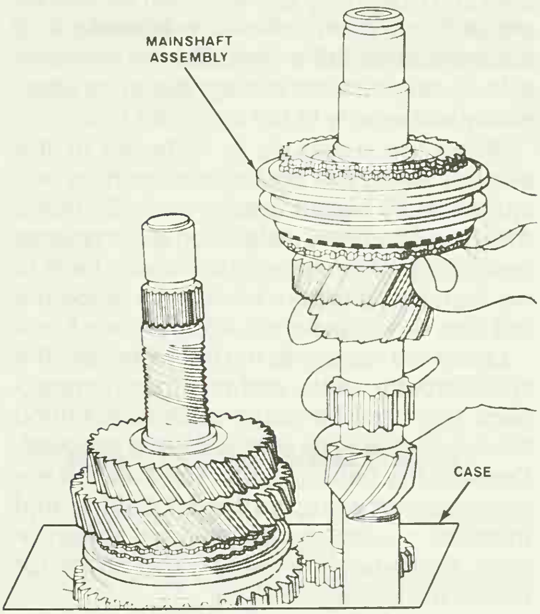


Figure 15-28. The partially assembled mainshaft is installed in the case. (Chrysler Corporation)

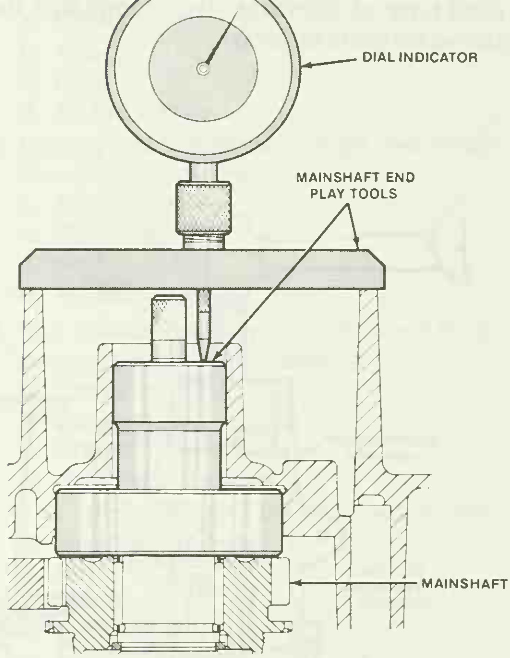


Figure 15-29. Mainshaft end play is measured and corrected with shims on the mainshaft. (Chrysler Corporation)

synchronizer grooves. Install the retaining clips that hold the linkage. Install the reverse shifting fork and support bracket. Replace the bracket bolts and tighten to the correct torque. Remount the transmission case onto the clutch housing. Using guide pins will help you align the two units as shown in Figure 15-30. Tighten the case bolts to the proper torque. Install the mainshaft bearing snap ring. Install the reverse idler shaft bolt and install the selector shaft assembly.

Install the remaining parts in this order: first install the mainshaft bearing retainer and washer in the case; then install the release lever assembly by pushing the parts into position and replacing the two retaining circlips. Install the release bearing and sleeve assembly in the case, replacing the clutch release end cover, using a new gasket. Put in the back-up light switch and clutch push rod. Place a new selector shaft boot seal over the selector shaft. Replace the axle drive flanges and snap rings on each axle. Fill the case to the correct level with the specified type of lubricant. This completes the transaxle parts buildup.

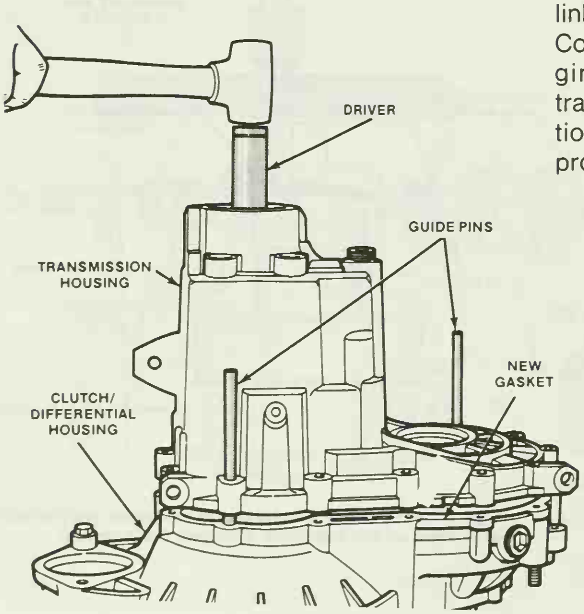


Figure 15-30. Installing the transmission case onto the clutch housing. (Chrysler Corporation)

JOB COMPETENCY 15-7 INSTALL THE TRANSAXLE IN A VEHICLE

Remove the transaxle from the bench or holding fixture and place it on a jack. Move the jack and transaxle under the vehicle. Raise the transaxle into position. Position the right side drive axle shaft into its bore as the transaxle is being installed. The right side shaft CANNOT be readily installed on some vehicles after the transaxle is connected to engine.

Slide the assembly up against the engine until the mainshaft enters the clutch. Rocking the assembly slightly will help align the mainshaft and clutch disc splines. When the splines are aligned, push the clutch housing into position against the engine. Start all the transaxle-to-engine bolts and tighten them alternately and evenly to the specified torque.

When the transaxle is fastened to the engine, swing the cradle into position and immediately install cradle-to-body bolts. After this operation, installation is the reverse procedure. When moving the cradle back to the installed position, be sure to guide the left side drive axle shaft into the case bore.

Lower the vehicle to the floor. Connect the speedometer cable and electrical connections. Connect the clutch cable and shifting linkage. Replace the starter, if it was removed. Connect the battery cable. Remove the engine support fixture after all engine and transaxle mounts are tightened to specifications. Road-test the vehicle and check for proper transaxle operation.

NEW TERMS

Circlips Self-locking rings that fit into a machined groove.

Cradle A subframe on the bottom of the engine compartment used to support the transaxle assembly.

Differential case bearing preload Preload on the differential case bearings adjusted with shims under the bearing cups.

Engine support A bar or pipe which is installed over the engine to hold it up when the transaxle is removed.

Mainshaft end play Movement end to end of the mainshaft controlled with shims under the end of the shaft.

Pinion bearing preload Preload on the pinion bearings adjusted with shims between the pinion shaft and the case.

JOB COMPETENCY TEST

1. How should the type of lubricant for a transaxle be determined?
2. How is the lubricant level in a transaxle determined?
3. Why is a careful troubleshooting procedure used to find a transaxle problem?
4. What vehicle noises can be confused with transaxle noise?
5. What is a transaxle troubleshooting guide?
6. What are the indications that a transaxle requires a shifter control adjustment?
7. How is a rear-drive transaxle removed?
8. What two ways are used to remove a front-drive transaxle?
9. What is a transaxle cradle?
10. How is a riveted ring gear removed from the differential case?

CERTIFICATION PRACTICE

1. Transaxle noises may be confused with noises from:
   a. Engine
   b. Wheel bearings
   c. Tires
   d. All the above
2. A transaxle is making a growling noise. Mechanic A says the problem is gear noise.
   Mechanic B the problem is bearing noise.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
3. A transaxle noise may occur during;
   a. Drive
   b. Float
   c. Coast
   d. All the above
4. A rough transaxle bearing may show up as a:
   a. Growl
   b. Knock
   c. Click
   d. All the above
5. Before the transaxle can be removed the engine must be:
   a. Supported
   b. Removed
   c. Both a and b
   d. Neither a nor b
6. The transaxle may be mounted to a removable subframe called a:
   a. Crossmember
   b. Support
   c. Cradle
   d. None of the above
7. The ring gear may be attached to the differential case with:
   a. Bolts
   b. Rivets
   c. Either a or b
   d. Neither a nor b

8. Differential case bearing preload is adjusted by:
   a. Shims between case and bearing
   b. Adjusting cups
   c. Shims between case and bearing cups
   d. None of the above
9. Pinion bearing preload must be adjusted when:
   a. Clutch housing is replaced
   b. Ring and pinion gear are replaced
   c. Differential bearings are replaced
   d. All the above
10. Mainshaft end play must be adjusted when:
   a. The case is replaced
   b. The clutch housing is replaced
   c. The mainshaft is replaced
   d. All the above

ANSWERS:

1.d, 2.b, 3.d, 4.d, 5.a, 6.c, 7.c, 8.c, 9.d, 10.d

DISCUSSION TOPICS AND ACTIVITIES

1. Road-test a vehicle with a transaxle problem. Use a troubleshooting guide to determine the problem.
2. Disassemble and reassemble a shop transaxle. Examine the parts and make a list of those requiring replacement.

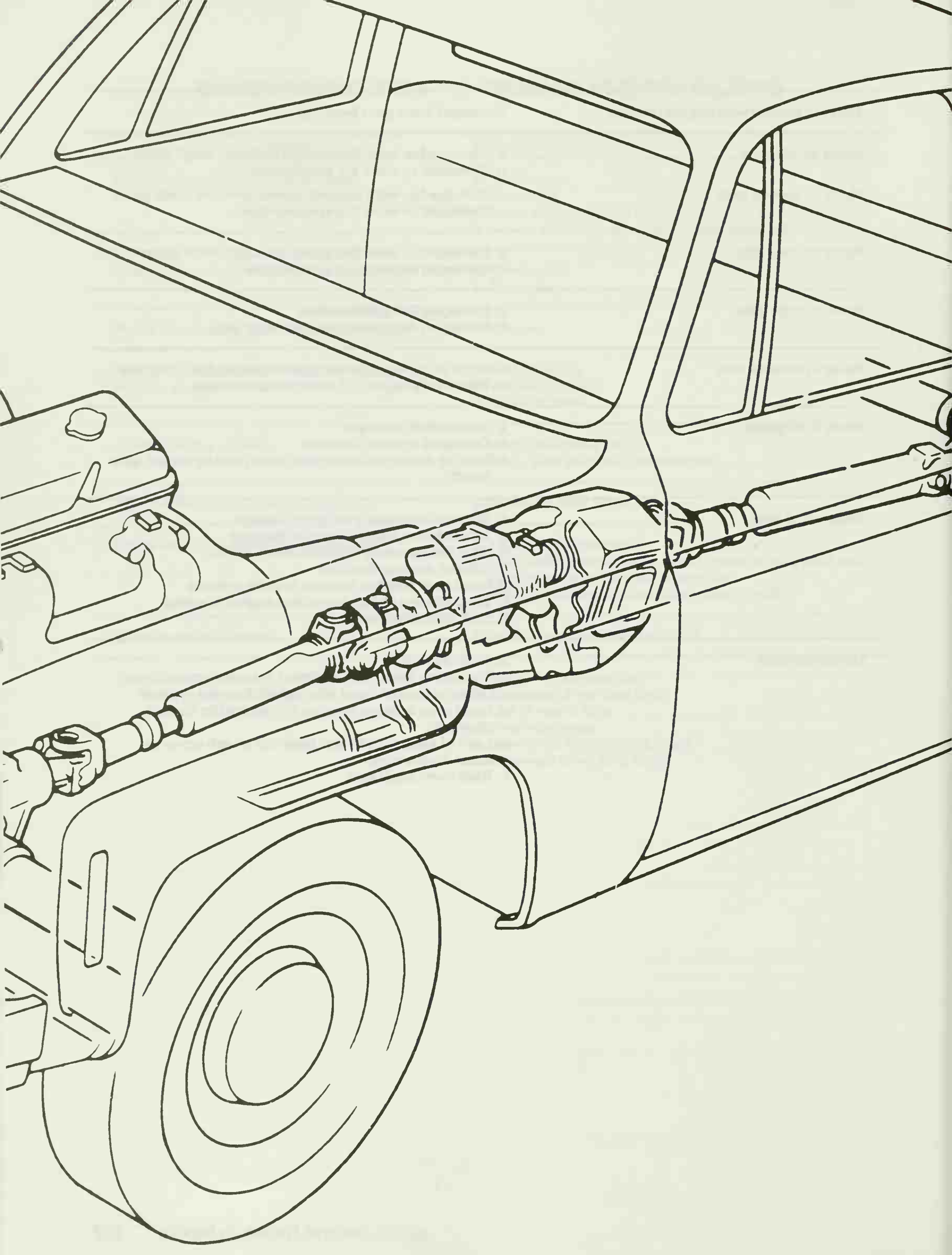
TRANSAXLE TECH CHECK

Possible Cause	Service
Hard Shifting	
1. Control linkage out of adjustment or lack of lubrication in ball joint	1. Readjust or lubricate
2. Failure of parts to reach their full stroke due to worn sliding contact surfaces or excessive free play	2. Check and, if necessary repair or replace worn parts
3. Improper contact pattern of ring-to-gear cone or worn parts	3. Replace worn parts
Gear Slippage	
1. Control linkage out of adjustment	1. Readjust
2. Steel ball worn, or locking spring fatigued or broken	2. Replace faulty parts
3. Worn groove in shift rod	3. Replace
4. Gear tip worn or damaged	4. Replace gear
5. Bushing worn	5. Replace
6. Excessive end play	6. Replace worn parts
7. Main shaft mounting nut loose	7. Retighten and bend lock washer firmly
Noise	
1. Lack of lubricating oil or use of improper oil	1. Lubricate or use recommended lubricant
2. Bearing worn (humming at high speeds)	2. Replace
3. Bearing damaged (rattling noise at low speeds)	3. Replace
4. Worn splines	4. Replace worn shaft or gear
5. Gear contact surfaces damaged	5. Replace damaged gears
6. Oil leakage or insufficient oil due to damaged oil seal or gasket, or clogged breather	6. Clean or replace
Abnormal noise when steering	
1. Differential gear damaged	1. Replace
2. Thrust washer worn excessively or damaged	2. Replace
3. Pinion shaft damaged	3. Replace
4. Side bearing seized or damaged	4. Replace
Gear noise	
1. Improper backlash in final gear	1. Replace final gear
2. Final gear tooth tip damaged	2. Replace final gear
3. Side bearing seized, broken, or damaged	3. Replace
4. Oil leakage (or lack of oil) due to faulty oil seal or gasket	4. Replace faulty parts

DIAGNOSIS GUIDE TO TRANSAXLE PROBLEMS

Condition	Probable Cause
Noise is the same in drive or coast	a. Road noise b. Tire noise c. Front wheel bearing noise d. Incorrect drive axle angle (Standing Height)
Noise changes on a different type of road	a. Road noise b. Tire noise
Noise tone lowers as car speed is lowered	Tire noise
Noise is produced with engine running, vehicle stopped or driving	a. Engine noise b. Transaxle noise c. Exhaust noise
A knock at low speeds	a. Worn drive axle joints b. Worn side gear hub counterbore
Noise most pronounced on turns	Differential gear noise
Clunk on acceleration or deceleration	a. Loose engine mounts b. Worn differential pinion shaft in case or side gear hub counterbore in case worn oversize c. Worn or damaged drive axle inboard joints
Clicking noise in turns	Worn or damaged outboard joint
Vibration	a. Rough wheel bearing b. Damaged drive axle shaft c. Out of round tires d. Tire unbalance e. Worn joint in drive axle shaft f. Incorrect drive axle angle

Noisy in neutral with engine running	Damaged input gear bearings
Noisy in first only	a. Damaged or worn first-speed constant mesh gears b. Damaged or worn 1-2 synchronizer
Noisy in second only	a. Damaged or worn second-speed constant mesh gears b. Damaged or worn 1-2 synchronizer
Noisy in third only	a. Damaged or worn 3rd speed constant mesh gears b. Damaged or worn 3-4 synchronizer
Noisy in high gear	a. Damaged 3-4 synchronizer b. Damaged 4th speed gear or output gear
Noisy in reverse only	a. Worn or damaged reverse idler gear or idler bushing b. Worn or damaged 1-2 synchronizer sleeve
Noisy in all gears	a. Insufficient lubricant b. Damaged or worn bearings c. Worn or damaged input gear (shaft) and/or output gear (shaft)
Slips out of gear	a. Worn or improperly adjusted linkage b. Transmission loose on engine housing c. Shift linkage does not work freely; binds d. Bent or damaged cables e. Input gear bearing retainer broken or loose f. Dirt between clutch cover and engine housing g. Stiff shift lever seal
Leaks lubricant	a. Axle shaft seals b. Excessive amount of lubricant in transmission c. Loose or broken input gear (shaft) bearing retainer d. Input gear bearing retainer O-ring and/or lip seal damaged e. Lack of sealant between case and clutch cover or loose clutch cover f. Shift lever seal leaks



Unit 16
Transfer Case

Up to this point we have described power train components used with a two-wheel drive either at the front or rear. For most driving, two-wheel drive is quite satisfactory. Cruising on good roads and highways, we get all the traction we need from the front or rear wheels. But, out in a rough or muddy field, or in loose sand or snow, two wheels driving may not be enough. To handle these conditions, vehicles are manufactured with four-wheel drive. With four-wheel drive, all four wheels are driven by the engine. This provides maximum traction. The heart of the four-wheel drive system is the transfer case. In this unit we will see how a transfer case operates to provide four-wheel drive.

LET'S FIND OUT

When you finish reading and studying this unit, you should be able to:

1. Explain the purpose of a transfer case.
2. Describe the components of a part-time transfer case.
3. Explain the power flow through a part-time transfer case.
4. Describe the components of a full-time transfer case.
5. Explain the power flow through a full-time transfer case.
6. Describe the operation of free-running front hubs.

TRANSFER CASE

A **transfer case** is a system of gears mounted in a separate housing behind the transmission. The purpose of the transfer case it to transfer or transmit engine power to two of the wheels for two-wheel drive or to all four wheels for four-wheel drive.

The transfer case provides power to a front drive shaft that delivers torque to a front axle. It also provides power to a rear shaft to transmit torque to a rear axle assembly. With this system we need a front driving axle with universal joints at the steering spindles so that the wheels can turn to steer the vehicle at the same time they are being driven. The

transfer case and drive system are shown in Figure 16-1.

There are two general types of transfer cases. One is described as a **part-time transfer case** system. With a part-time system the vehicle may use either two- or four-wheel drive. During normal driving the vehicle uses two-wheel drive. When rough or slippery roads are encountered, the driver engages the gears in the transfer case to deliver power to all four wheels. The other type, the **full-time transfer case**, provides full-time four-wheel drive. With this system the transfer case sends power to each of the four wheels. Both types of transfer cases also provide a gear reduction range lower than the transmission low gear to increase vehicle power in steep conditions.

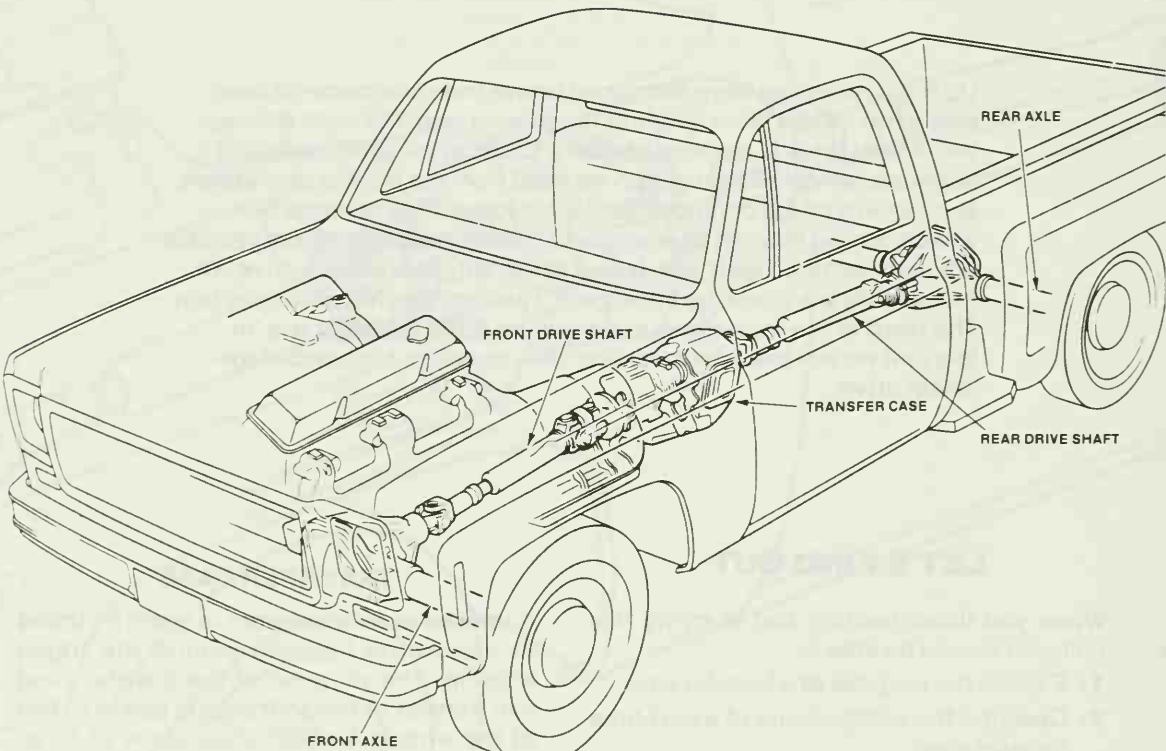


Figure 16-1. Transfer case provides power to the rear axle or both axles. (GMC Truck and Coach Division of General Motors Corporation)

PART-TIME TRANSFER CASE COMPONENTS

The transfer case is mounted to the rear of the transmission. The transfer case input shaft is splined to the transmission output shaft. Splined to the transfer case input shaft, as shown in Figure 16-2, is the transfer case main drive gear. Anytime there is an input to the transfer case, the main drive gear turns.

In the center of the transfer case is the idler shaft two-gear cluster, shown in Figure 16-3. Two gears—the idler shaft drive gear and the idler shaft low-speed gear—are machined from the same piece of stock. The idler shaft drive gear is always in mesh with the input shaft main drive gear. Therefore, the idler shaft gears also turn whenever there is an input from the transmission.

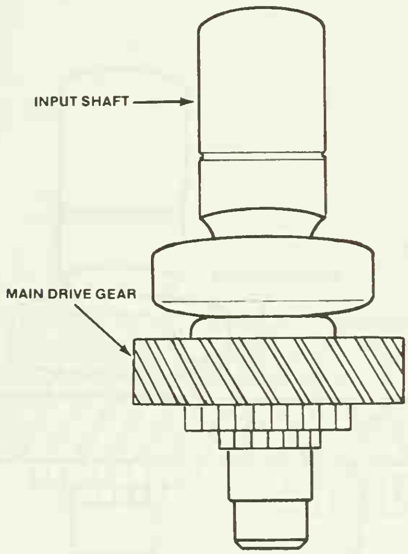


Figure 16-2. The main drive gear is driven by the transfer case input shaft.

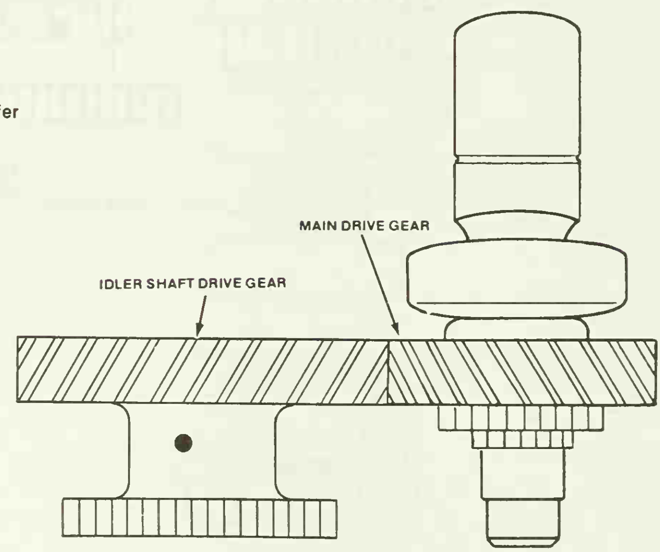


Figure 16-3. The idler shaft gears mesh with the main drive gear.

The front output high-speed gear shown in Figure 16-4 is in constant mesh with the idler shaft drive gear. In neutral, it runs free on the front output shaft. The high-speed gear has the same number of teeth as the main drive gear, so it will always turn with the main drive gear—at the same speed and in the same direction.

Now, we have assembled the complete system of gears involved in input to the transfer case—the main drive gear, the two idler shaft gears, and the front output high-speed gear. All four input gears are in constant mesh in the transfer case at all times, and all four turn whenever the input shaft turns.

To get the drive out of the transfer case to the wheels, we must have an output shaft (or shafts) and some way to couple it (them) to the input drive.

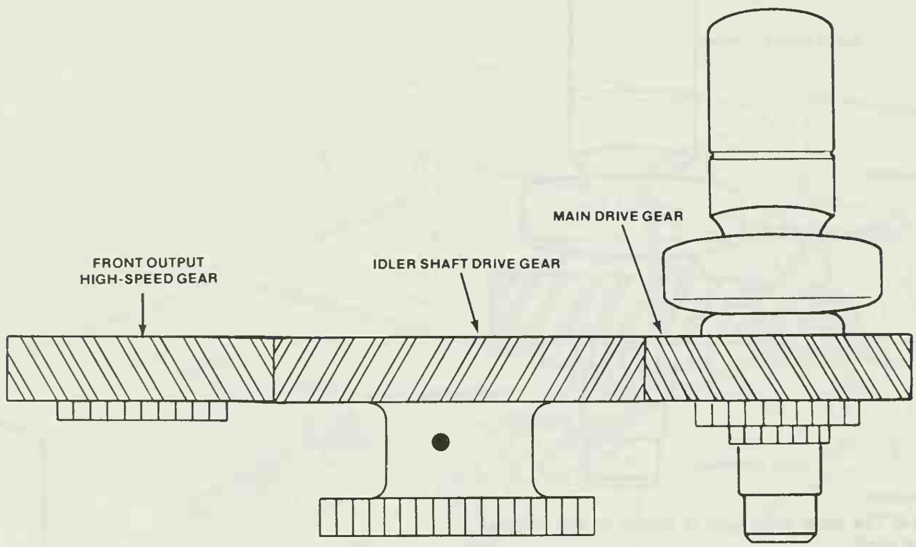


Figure 16-4. The front output high-speed gear is in mesh with the idler shaft drive gear.

The rear output shaft shown in Figure 16-5 is mounted in the transfer case on the same center line as the input shaft. Splined to the output shaft is a sliding gear and clutch. The sliding gear and clutch are shown in the neutral position. The sliding gear can move forward to engage the clutch teeth on the main drive gear, thus locking the output shaft to the input shaft for direct drive. The sliding gear and clutch also can move towards the rear to mesh with the idler shaft low-speed gear, permitting the idler shaft to drive the rear output shaft for reduction.

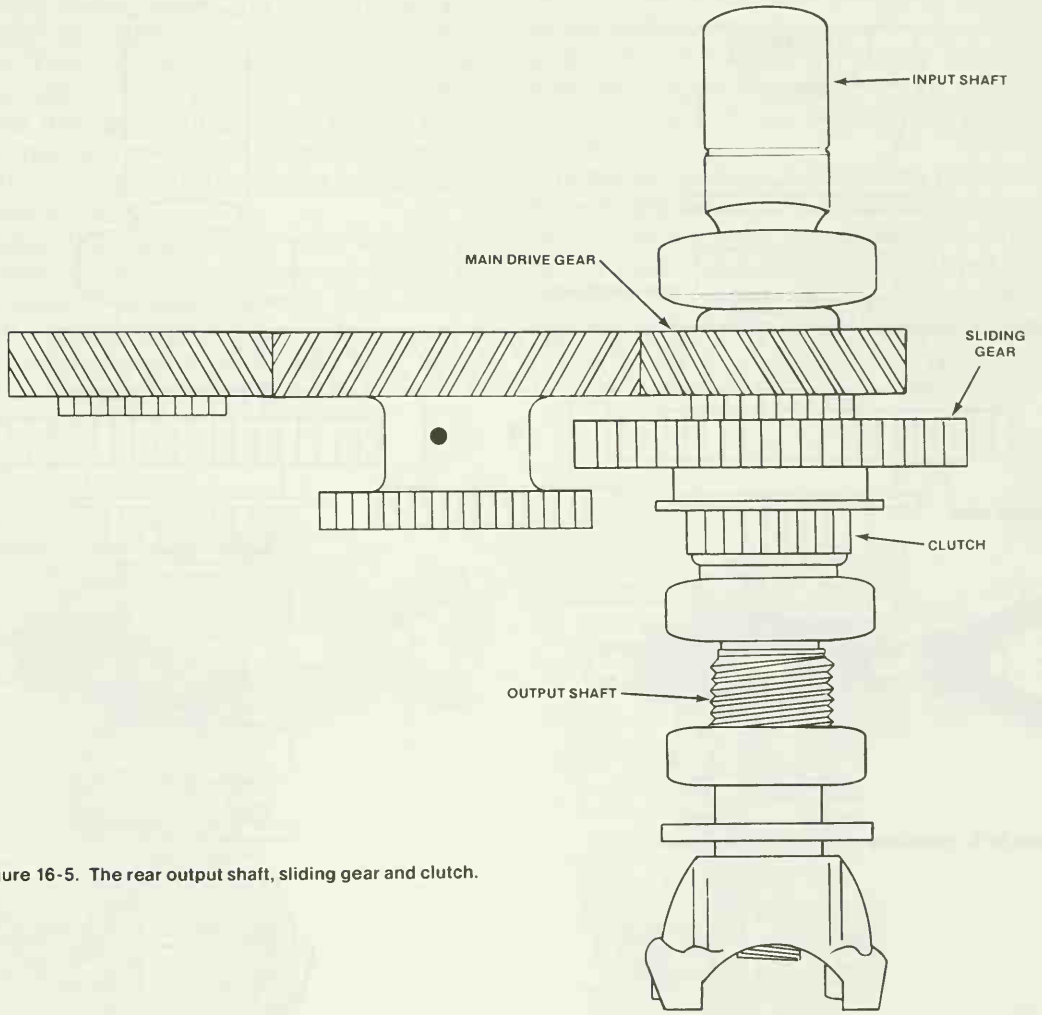


Figure 16-5. The rear output shaft, sliding gear and clutch.

For front-wheel drive, we have the front output shaft, shown in Figure 16-6, which supports the front output high-speed gear. This shaft also has a sliding gear and clutch splined to it.

The front output shaft sliding gear and clutch (shown in neutral) can move forward to lock the output shaft to the high-speed gear for direct drive, or it can move rearward to mesh with the idler shaft low-speed gear and drive the front output shaft in reduction.

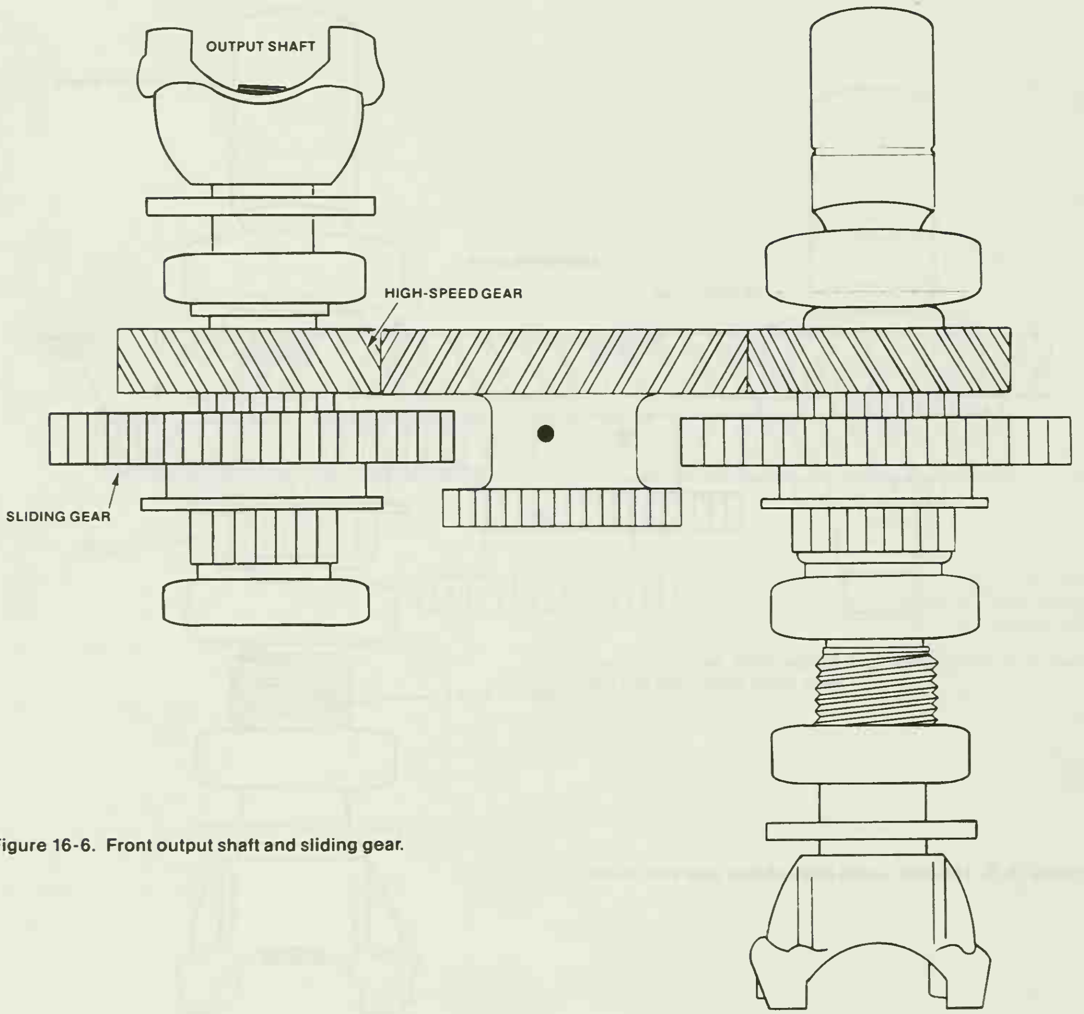


Figure 16-6. Front output shaft and sliding gear.

PART-TIME TRANSFER CASE OPERATION

There are four positions for the transfer case shift lever, which is located on the floor. They are:

4L — 4-wheel drive low
N — Neutral
2H — 2-wheel drive high (rear wheels only)
4H — 4-wheel drive high

Gears in the transfer case are shifted by moving sliding gears. The sliding gears are moved by forks connected to two shift rails. The shift rails are connected to the floor shift lever through an adjustable **clevis** linkage. Spring-loaded detent balls and interlock pins fall into notches in the shift rails to give the driver the feel of completed shifts.

When the transfer case shift lever is in neutral, the sliding gears are not locked to the main drive gear or to the front output shaft high-speed gear, nor are they meshed with the idler shaft low-speed gear. They simply idle as shown in Figure 16-7.

When the driver moves the transfer case shift lever rearward to the 2H position, the rear output shaft sliding gear is moved fully forward and engages with the main drive gear as shown in Figure 16-8. This locks the main drive gear to the rear output shaft. The front output shaft sliding gear remains in the neutral position so the high-speed gear is still free-running and there is no action at the front axle.

Power flow in 2H, then, is straight through the input shaft and main drive gear, the rear output shaft sliding gear, the rear output shaft, and to the rear-wheel drive shaft. Power is transmitted through the transfer case to the rear axle only and without a change in gear ratio.

In the 4H position, both sliding gears are moved fully forward. The rear output sliding gear locks the main drive gear to the rear output shaft, just as in 2H. Also, the front output shaft sliding gear locks the front output shaft to the front output shaft high-speed gear.

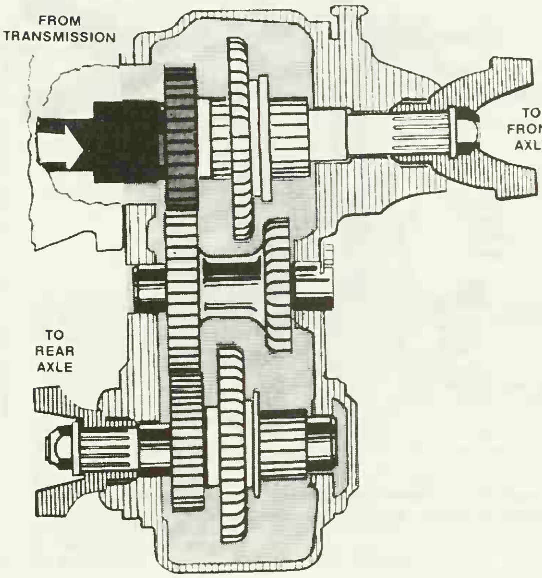


Figure 16-7. Power through the transfer case in neutral. (American Motors Corporation)

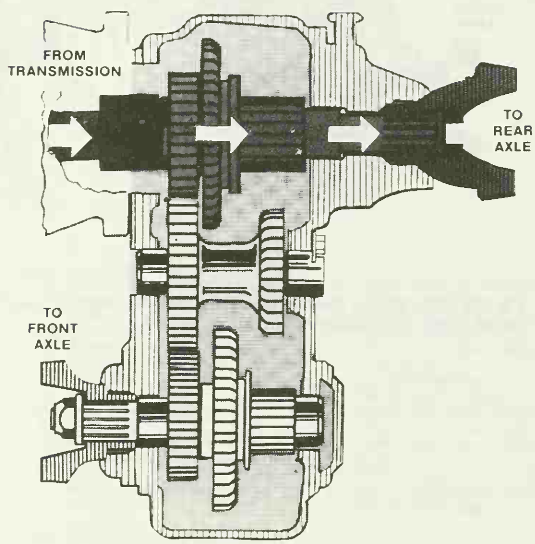


Figure 16-8. Power flow in two-wheel drive. (American Motors Corporation)

Power flow in 4H splits at the main drive gear as shown in Figure 16-9. It continues through to the rear output shaft and also goes through the idler shaft drive gear to the high-speed gear and to the front output shaft.

When the driver moves the shift lever to 4L, the shift rails move both sliding gears towards the rear to mesh with the idler shaft low-speed gear. Since the sliding gears are splined to the output shafts, the idler low-speed gear can drive both output shafts.

Power flow then is from the input shaft and main drive gear, as shown in Figure 16-10, to the idler gears. At the idler low-speed gear, the power splits and continues through the sliding gears and output shafts to the front and rear drive shafts.

The transfer case gear reduction is from the main drive gear to the larger idler shaft drive gear and also from the idler (smaller) low-speed gear to the larger sliding gears. The transfer case reduction in 4L is about 2.50 to 1. The drive shafts make one revolution for each 2.46 revolutions of the transmission output shaft, and the torque is multiplied 2.50 times.

In the high ranges (2H and 4H), the transfer case sends transmission output shaft torque to the driving axles without any reduction or multiplication. In other words, the drive shaft torque is the same as the transmission output shaft torque.

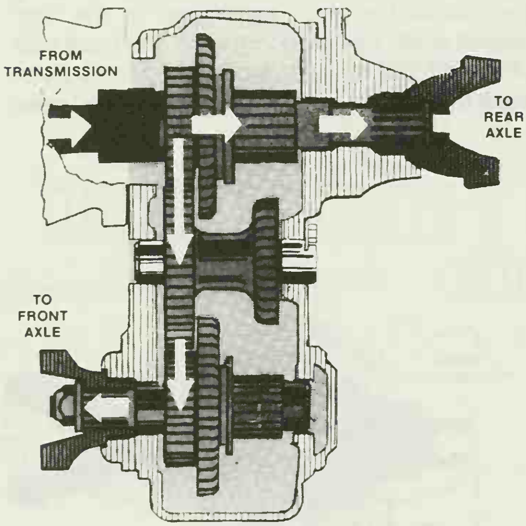


Figure 16-9. Power flow through the transfer case in four-wheel drive. (American Motors Corporation)

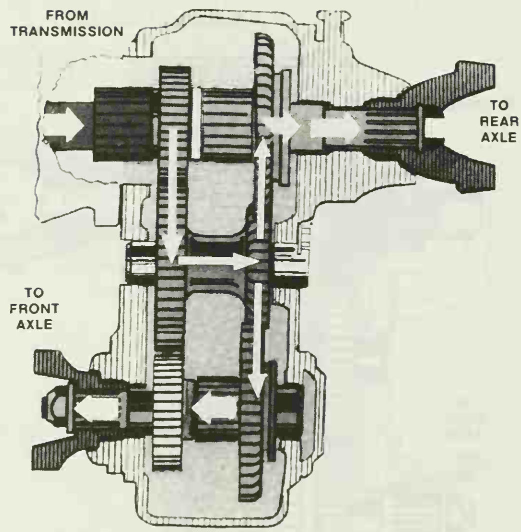
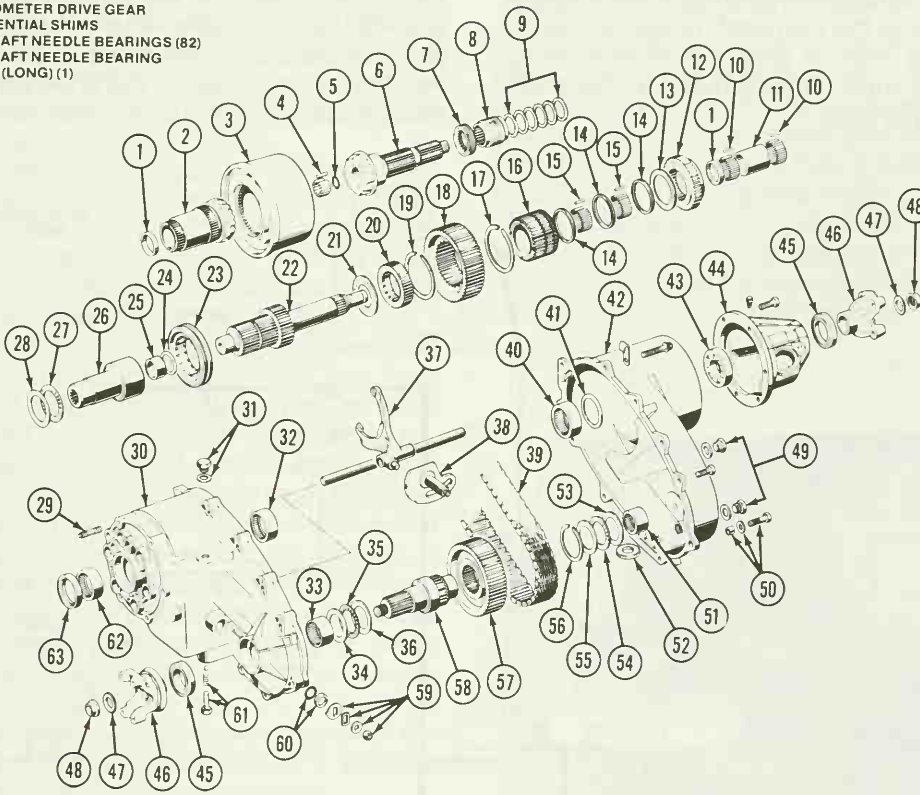


Figure 16-10. Power flow through the transfer case in four-wheel drive low. (American Motors Corporation)

FULL-TIME TRANSFER CASE OPERATION

The full-time transfer case provides fully differentiated four-wheel drive in all operating conditions. Four-wheel drive range is automatic and does not require any external linkage for four-wheel operation. Some units have a four-wheel drive low range, and others do not. The components of a full-time transfer case are shown in Figure 16-11.

1. MAINSHAFT BEARING SPACERS (SHORT) (2)
2. SIDE GEAR
3. VISCOUS COUPLING
4. MAINSHAFT PILOT BEARINGS
5. MAINSHAFT O-RING
6. REAR OUTPUT SHAFT
7. OIL PUMP
8. SPEEDOMETER DRIVE GEAR
9. DIFFERENTIAL SHIMS
10. MAINSHAFT NEEDLE BEARINGS (82)
11. MAINSHAFT NEEDLE BEARING SPACER (LONG) (1)



12. CLUTCH GEAR
13. CLUTCH GEAR THRUST WASHER
14. SPROCKET CARRIER NEEDLE BEARING SPACER (3)
15. SPROCKET CARRIER NEEDLE BEARINGS (120)
16. SPROCKET CARRIER
17. SPROCKET CARRIER SNAP RING
18. DRIVE SPROCKET
19. SPROCKET CARRIER SNAP RING
20. SPLINE GEAR
21. MAINSHAFT THRUST WASHER
22. MAINSHAFT
23. CLUTCH SLEEVE
24. MAINSHAFT THRUST WASHER
25. MAINSHAFT BUSHING
26. INPUT GEAR
27. INPUT GEAR THRUST BEARING
28. INPUT GEAR THRUST BEARING RACE
29. MOUNTING GEAR
30. FRONT CASE
31. PLUG AND WASHER
32. INPUT GEAR REAR BEARING
33. FRONT OUTPUT SHAFT FRONT BEARING
34. FRONT OUTPUT SHAFT FRONT THRUST BEARING RACE (THICK)
35. FRONT OUTPUT SHAFT FRONT THRUST BEARING
36. FRONT OUTPUT SHAFT FRONT THRUST BEARING RACE (THIN)
37. RANGE FORK AND RAIL
38. RANGE SECTOR
39. DRIVE CHAIN
40. REAR OUTPUT SHAFT BEARING
41. REAR OUTPUT SHAFT BEARING SEAL
42. REAR CASE
43. REAR OUTPUT BEARING
44. REAR RETAINER
45. YOKE SEAL
46. YOKE
47. SEAL WASHER
48. YOKE NUT
49. FILL AND DRAIN PLUGS
50. ALIGNMENT DOWEL, WASHER AND BOLT
51. FRONT OUTPUT SHAFT REAR BEARING
52. MAGNET
53. FRONT OUTPUT SHAFT REAR THRUST BEARING RACE (THICK)
54. FRONT OUTPUT SHAFT REAR THRUST BEARING
55. FRONT OUTPUT SHAFT REAR THRUST BEARING RACE (THIN)
56. DRIVEN SPROCKET RETAINING SNAP RING
57. DRIVEN SPROCKET
58. FRONT OUTPUT SHAFT
59. RANGE SECTOR SHAFT RETAINING LOCKNUT AND WASHERS
60. RANGE SECTOR SHAFT SEAL AND RETAINER
61. DETENT BALL, SPRING AND BOLT
62. INPUT GEAR FRONT BEARING
63. INPUT GEAR SEAL

Figure 16-11. Exploded view of a full-time transfer case assembly. (American Motors Corporation)

The fully differentiated operation is accomplished through a torque dividing fluid or viscous coupling and an open differential connected to the coupling. Two drive sprockets and an interconnecting drive chain are used to distribute torque to the front and rear propeller shafts. The case assembly is made of cast aluminum. It has front and rear case halves and a rear retainer.

All input torque is transmitted to the transfer case gear train through the input gear which is splined to the transmission output shaft. Since the mainshaft is also splined to the input gear as shown in Figure 16-12, torque is transmitted directly to the mainshaft by the gear.

Torque flows through the mainshaft to the differential pinions and pinion carrier (in the viscous coupling) which are splined to the mainshaft. Torque flows directly to the rear output shaft through the shaft side gear which is meshed with the coupling differential pinions. Torque then flows to the rear drive shaft and axle through the rear output shaft.

Torque is applied to the drive sprocket through the side gear which is meshed with the coupling differential pinions. Mainshaft torque flows through the pinions and side gear to the clutch gear which is splined to both the viscous coupling and sprocket carrier. Torque then flows to the drive sprocket through the sprocket carrier which is splined

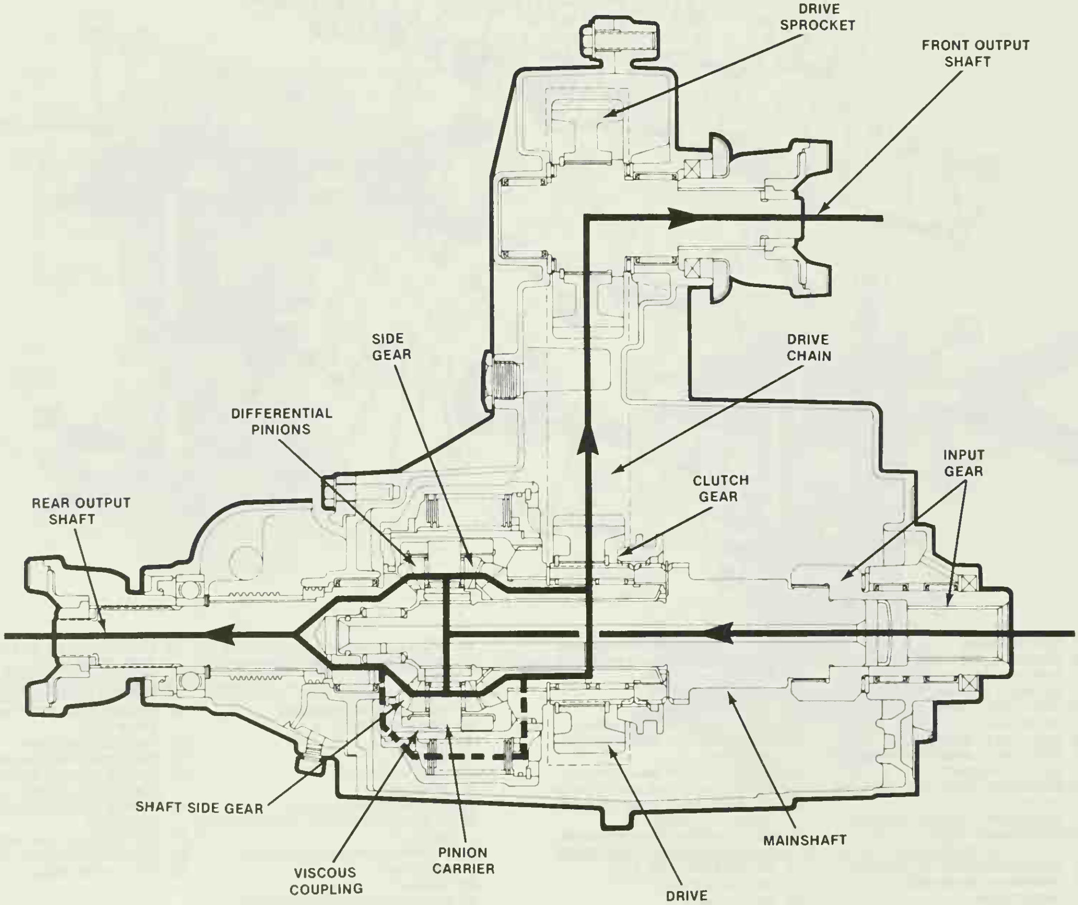


Figure 16-12. Power flow through a full-time transfer case. (American Motors Corporation)

to the drive sprocket. Torque is further transmitted to the front output shaft by the drive chain that interconnects the drive and driven sprockets. The clutch sleeve is not meshed and remains in a neutral position at all times.

The differential assembly consists of the side gear, the rear output shaft, the viscous coupling, and the differential pinion gear assembly. The differential operates in the same way as a standard differential. In straight ahead driving, the differential and coupling rotate as a unit. On turns, the differential allows the front and rear axles to operate at their own speeds. This occurs because the pinions are free to rotate around the side gear and rear output shaft gear teeth at differing speeds.

The viscous coupling functions as a torque dividing slip-limiting unit. It consists of an enclosed housing containing two sets of fixed clutch plates and a special silicone fluid. The differential pinion gears are located in the open center section of the coupling.

The coupling is connected to the front drive shaft through the side gear and drive sprocket which operates the driven sprocket and front output shaft via the drive chain. The rear drive shaft is connected to the coupling through the rear output shaft side gear teeth which are meshed with the differential pinions. In normal operation, the coupling is not active. Front/rear axle speed differences that produce drive line torque loads are dissipated by the differential. However, when extreme speed variations between axles occur, such as when one wheel or set of wheels spins on an ice-covered surface, the coupling acts to transfer torque to the axle wheels having the greater traction.

The special silicone fluid in the enclosed portion of the coupling is highly viscous and does not thin out when heated or subjected to high shear forces. In operation, when one axle overspeeds due to wheel slip, input to coupling causes the coupling rotational speed to increase also. However, as coupling speed increases, the fixed clutch plates in the coupling are also forced to rotate (shear) through the silicone fluid at higher speeds. As the fluid is forced between the plates, it is displaced and expands, creating shear friction, and resists further increases in input speed. This resistance to rotating speed increases in direct proportion to the increase in input speed from the front or rear axle through the drive shaft.

In situations where the coupling becomes operational, the coupling does not lock the axles together to produce undifferentiated four-wheel drive. The coupling merely limits (controls) the amount of slippage while delivering maximum torque to the axle having the greater traction.

FOUR-WHEEL DRIVE FRONT HUBS

When a full-time four-wheel drive transfer case is used, the front drive axle hubs are connected solidly through splines to the wheel hubs. In the standard axle shown in Figure 16-13, the wheel hub, a **locked hub** is splined to a driving hub which is splined to the outer end of the axle shaft. The hub is similar to that used on a rear axle except that provision must be made to rotate on ball joints or king pins to allow steering.

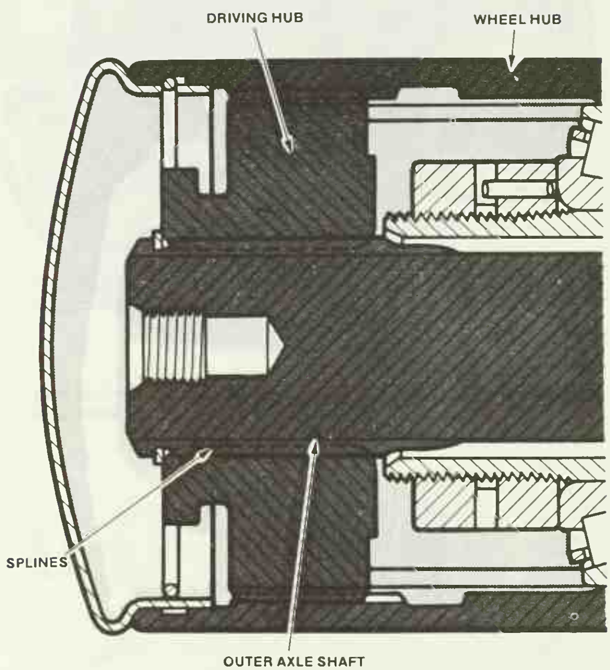


Figure 16-13. Full-time transfer case units use hubs that are locked to the drive axles by splines. (Ford Motor Company)

With a part-time drive transfer case it is desirable to unlock the hubs from the driving axle when the unit is in two-wheel drive. The reason is that we do not want the axle shafts turning with the wheels when in 2-wheel drive, because when the axle shafts turn, the differential and the front drive shaft will have to turn, too. When the axles are turning, there is a great deal of added friction which increases wear and decreases fuel mileage. Part-time drive units eliminate this problem by using front hubs with clutches that allow the driver to unlock or lock the hub to the axle.

Figure 16-14. Clutch-type hubs are locked and unlocked with selector levers on the outside of the hub. (GMC Truck and Coach Division of General Motors Corporation)

The **free-running clutch hub** is activated by a selector lever on the outside of the hub. The driver can rotate the selector lever to the lock or unlock position as shown in Figure 16-14.

In the free-running hub shown in Figure 16-15, a spring-loaded jaw clutch is used to lock the wheel hub to the axle shaft. The inner jaw is splined to the wheel hub. The outer jaw is splined to the axle shaft. When in the lock position the inner jaw is locked to the outer jaw. The axle shaft drives the hub through the clutch.

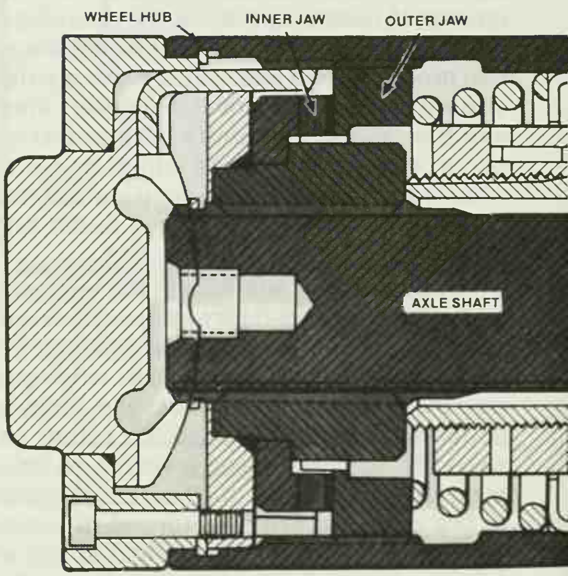


Figure 16-15. A freewheeling clutch hub in the locked position. (Ford Motor Company)

Unlocking the jaw clutch is achieved by turning the selector knob on the end of the hub 90 degrees either way. When the knob is turned, cam action forces the outer jaw back out of engagement with the inner jaw as shown in Figure 16-16. The front wheels can roll without dragging the axle and drive shaft. An exploded view of a free-running clutch is shown in Figure 16-17.

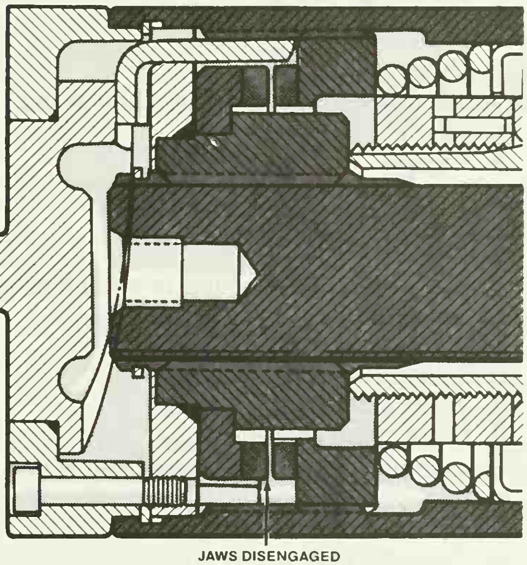
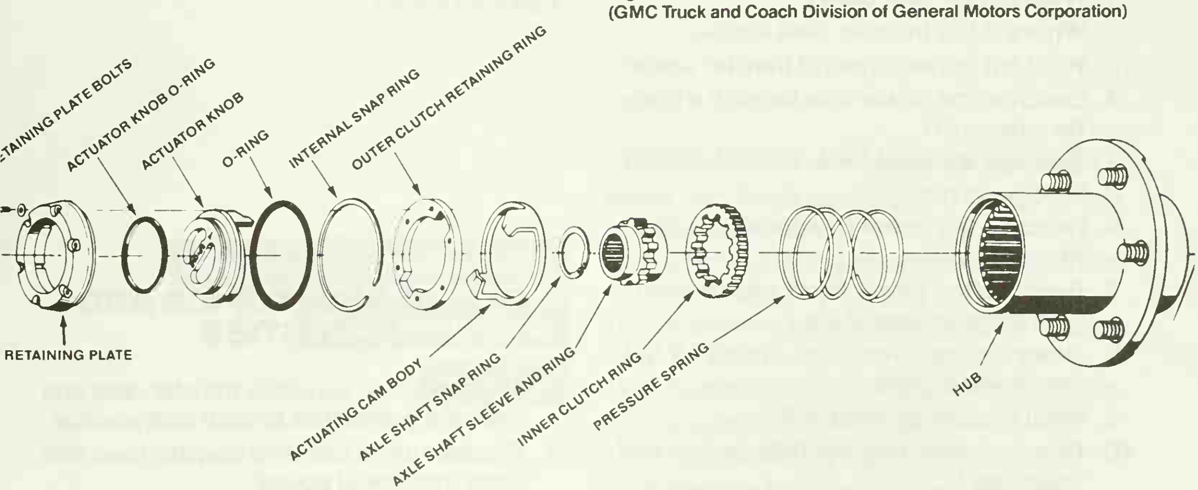


Figure 16-16. A freewheeling clutch hub in the unlocked position. (Ford Motor Company)

Figure 16-17. An exploded view of a free-running clutch hub. (GMC Truck and Coach Division of General Motors Corporation)



NEW TERMS

Clevis A forked shape unit used to join linkage together.

Free-running clutch hub A type of hub used with part-time four-wheel drive in which the drive axle may be engaged or disengaged from the hub.

Full-time transfer case A transfer case that provides four-wheel drive under all road conditions.

Locked hub A type of four-wheel drive hub in which the axle is splined directly to the hub and provides a positive lockup at all times.

Part-time transfer case A transfer case that allows the driver to select two- or four-wheel drive by shifting gears in the case.

Transfer case A system of gears in a housing behind the transmission that directs power to a front and rear drive axle.

CHECK YOURSELF

1. What is a transfer case?
2. Where is the transfer case located?
3. What are the two types of transfer cases?
4. Describe the power flow through a transfer case in 2H.
5. Describe the power flow through a transfer case in neutral.
6. Describe the power flow through a transfer case in 4L.
7. Describe the power flow through a part-time transfer case in 4H.
8. Describe the power flow through a full-time transfer case.
9. What is a locked front hub?
10. How is a free-running hub locked and unlocked?

CERTIFICATION PRACTICE

1. A part-time transfer case provides power to all four wheels in:
   a. 4H
   b. 4L
   c. Both a and b
   d. Neither a nor b
2. The gear assembly in the center of a part-time transfer case is called:
   a. Main drive
   b. Idler shaft
   c. High speed
   d. Output shaft
3. Power flows across the idler shaft in the transfer case in:
   a. Neutral
   b. Two-wheel drive
   c. Four-wheel drive
   d. None of the above
4. Torque biasing is provided in a full-time transfer case by:
   a. Idler shaft
   b. Torque converter
   c. Viscous coupling
   d. None of the above
5. Freewheeling clutch hubs are used with:
   a. Two-wheel drive
   b. Full-time four-wheel drive
   c. Part-time four-wheel drive
   d. None of the above

ANSWERS:

1. c, 2. b, 3. c, 4. c, 5. c

DISCUSSION TOPICS AND ACTIVITIES

1. Disassemble a part-time transfer case and trace the power flow in each shift position.
2. Disassemble a full-time transfer case and trace the flow of power.

Unit 17
Transfer Case Service

Transfer cases are designed for very heavy duty service. These units work for many thousands of miles before they require service. If the transfer case is operated when it is low on lubricant or shifted roughly, the internal components can be damaged. In this unit we will describe the preventive maintenance, troubleshooting, and service procedures used to service a transfer case.

Preventive Maintenance

Troubleshooting

Service

DEVELOPING JOB COMPETENCIES

When you finish reading and studying this unit, you should be able to:

17-1 Check, drain, and refill the lubricant in a transfer case.

17-2 Perform a trouble diagnosis on a transfer case.

17-3 Remove a transfer case from a vehicle.

17-4 Disassemble a transfer case.

17-5 Reassemble a transfer case.

17-6 Install a transfer case in a vehicle.

JOB COMPETENCY 17-1 CHECK, DRAIN, AND REFILL THE LUBRICANT IN A TRANSFER CASE

The transfer case is lubricated like a manual transmission. A lubricant is splashed onto the components by the turning gears. In order to have proper lubrication, the transfer case must have the correct level of the proper lubricant.

To check the lubricant level, raise the vehicle on a hoist and make sure it is level. Locate the fill plug (Figure 17-1) on the front or side of the case. Remove the plug. The lubricant level should be even with the fill plug hole. If necessary add the recommended type of lubricant to establish the correct level. Replace the fill plug and lower the vehicle.

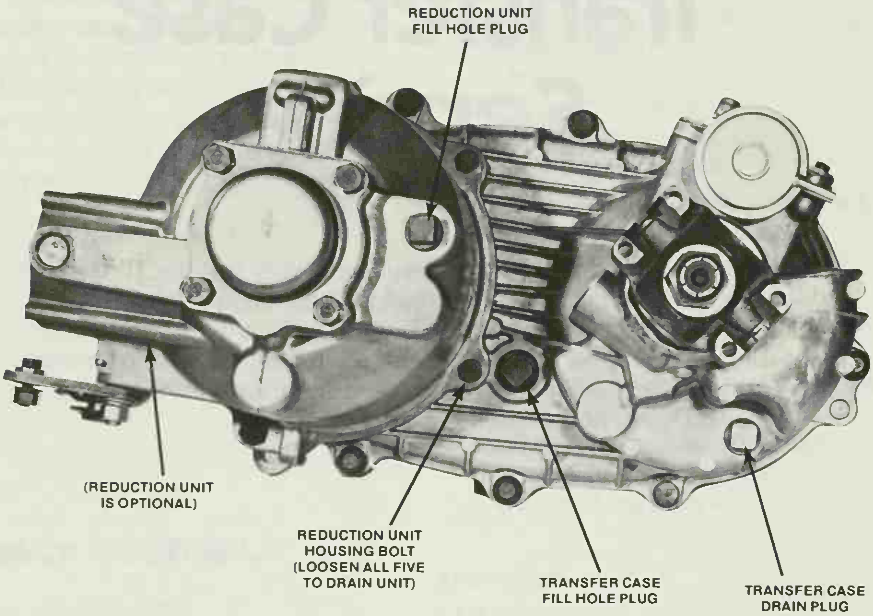


Figure 17-1. The fill plug is used to fill and inspect lubricant level. (American Motors Corporation)

Some manufacturers specify regular drain intervals for the transfer case. Drain plugs are generally not provided on the cases. To drain the lubricant raise the vehicle on a hoist and make sure it is level. The lubricant is removed on some units by removing a power take-off cover or removing the lowest bolt from the output shaft rear bearing retainer as shown in Figure 17-2. Remove the fill plug to vent the case as it is draining. Replace the cover or bolt after all the lubricant has drained. Fill the unit to the correct level with the recommended type of lubricant. Lower the vehicle.

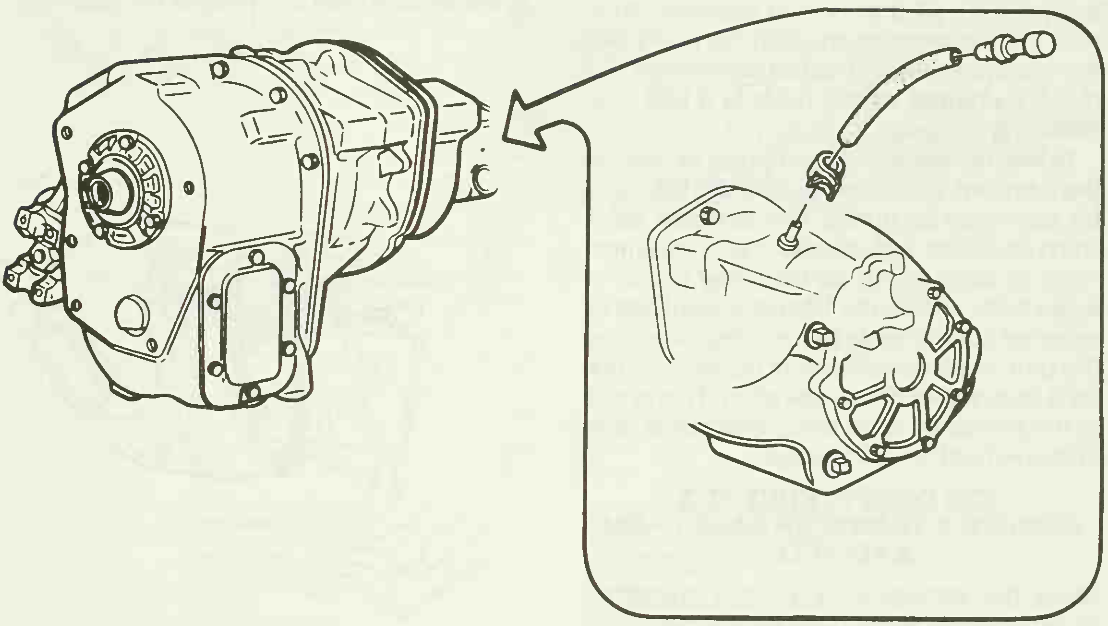


Figure 17-2. Lubricant is drained by removing a power take-off plate or the lowest bolt in the rear bearing retainer. (GMC Truck and Coach Division of General Motors Corporation)

JOB COMPETENCY 17-2 PERFORM A TROUBLE DIAGNOSIS ON A TRANSFER CASE

Before trying to repair a suspected transfer case malfunction, check all other drive line components. The actual cause of a problem may be related to the axles, hubs, drive shafts, wheels and tires, or transmission. If all other drive line components are in good condition and operating properly, road-test the vehicle. If a manufacturer's diagnosis chart is available, use it during the road test to help isolate the problem.

Deciding whether the gear trouble is in the transfer case or in the transmission is easier with a part-time transfer case because of the location of the neutral position. Running the transmission through the gears with the transfer case in neutral should tell you quickly whether or not there is a bad gear in the transmission.

Drive the vehicle long enough to heat up the lubricant. Excessive noise from the transfer case may be due to low lubricant level, worn bearings, a damaged chain, misalignment of drive shafts or universal joints, or loose bolts. Check the lubricant level and all external components before disassembling the unit. A slight increase in noise is normal for a four-wheel drive operation. This is due to the additional drive line components used in four-wheel drive vehicles.

JOB COMPETENCY 17-3 REMOVE A TRANSFER CASE FROM A VEHICLE

Raise the vehicle on a hoist or support it on jack stands. Support the engine and transmission with a support stand or transmission jack. Disconnect the catalytic converter or other exhaust components that may interfere with the transfer case. Remove the **skid plate.** Remove the speedometer cable and **adapter** from the transfer case. Discard the adapter O-ring; it is not reusable.

Mark the drive shafts and transfer case yokes for assembly reference. Disconnect the drive shafts at the yokes. Secure the shafts to the underside of the automobile. Disconnect the gearshift linkage at the transfer case. Remove the rear crossmember. Remove the transfer case-to-adapter housing stud nuts or bolts (Figure 17-3) and move the transfer case to the rear until the input shaft clears the adapter. Lower the assembly from under the vehicle.

JOB COMPETENCY 17-4 DISASSEMBLE A TRANSFER CASE

Always locate and follow the specific manufacturer's instructions when overhauling a transfer case. An exploded view of the assembly similar to that shown in Figure 17-4 is helpful in disassembly and reassembly.

Remove the shift lever assembly. Remove the bottom cover and gaskets. Remove the bolts attaching the rear bearing cup assembly to the transfer case and remove the assembly.

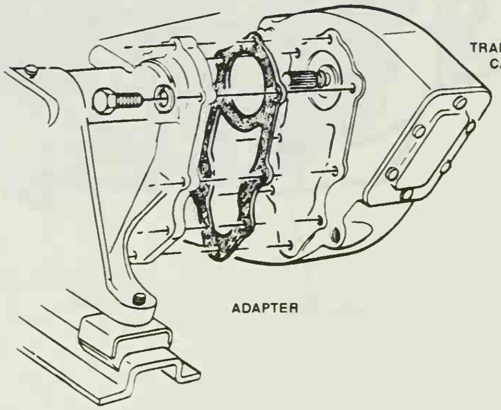
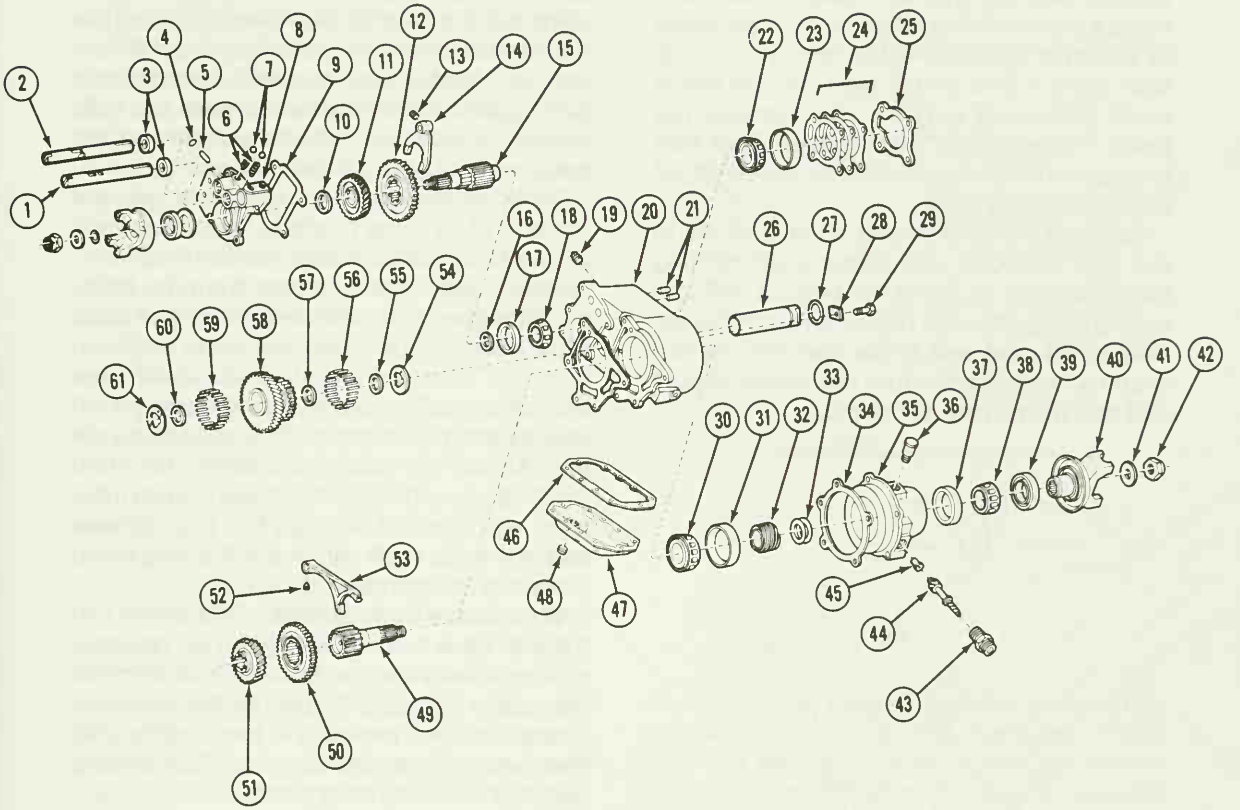


Figure 17-3. After the bolts from the adapter to the transfer case are removed, the units can be separated. (GMC Truck and Coach Division of General Motors Corporation)

Remove the intermediate shaft lock plate. Using an arbor driving tool and plastic mallet, drive the intermediate shaft out the rear of the

Figure 17-4. An exploded view of the transfer case. (American Motors Corporation)



1. SHIFT ROD—REAR OUTPUT SHAFT SHIFTING FORK
2. SHIFT ROD—FRONT OUTPUT SHAFT SHIFTING FORK
3. SHIFT ROD OIL SEAL
4. INTERLOCK PLUG
5. INTERLOCK
6. POPPET BALL SPRING
7. POPPET BALL
8. FRONT BEARING CAP
9. FRONT BEARING CAP GASKET
10. FRONT OUTPUT SHAFT THRUST WASHER
11. FRONT OUTPUT SHAFT GEAR
12. FRONT OUTPUT SHAFT SLIDING GEAR
13. SETSCREW
14. FRONT OUTPUT SHAFT SHIFTING FORK
15. FRONT OUTPUT SHAFT
16. FRONT OUTPUT SHAFT SPACER
17. FRONT OUTPUT SHAFT FRONT BEARING CUP
18. FRONT OUTPUT SHAFT FRONT BEARING
19. FILLER PLUG
20. TRANSFER CASE
21. THIMBLE COVER
22. FRONT OUTPUT SHAFT REAR BEARING
23. FRONT OUTPUT SHAFT REAR BEARING CUP
24. FRONT OUTPUT SHAFT REAR BEARING CUP SHIMS
25. COVER PLATE
26. INTERMEDIATE SHAFT
27. INTERMEDIATE SHAFT O-RING
28. LOCK PLATE
29. LOCK PLATE BOLT
30. REAR OUTPUT SHAFT FRONT BEARING
31. REAR OUTPUT SHAFT FRONT BEARING CUP
32. SPEEDOMETER DRIVE GEAR
33. REAR OUTPUT SHAFT BEARING SHIM
34. REAR BEARING CAP GASKET
35. REAR BEARING CAP
36. BREATHER
37. REAR BEARING CAP CUP
38. REAR BEARING CAP BEARING
39. REAR BEARING CAP OIL SEAL
40. REAR YOKE
41. REAR YOKE WASHER
42. REAR YOKE NUT
43. SPEEDOMETER SLEEVE
44. SPEEDOMETER DRIVEN GEAR
45. SPEEDOMETER BUSHING
46. BOTTOM COVER GASKET
47. BOTTOM COVER
48. DRAIN PLUG
49. REAR OUTPUT SHAFT
50. REAR OUTPUT SHAFT SLIDING GEAR
51. MAINSHAFT GEAR
52. SETSCREW
53. REAR OUTPUT SHAFT SHIFTING FORK
54. INTERMEDIATE GEAR THRUST WASHER
55. INTERMEDIATE GEAR BEARING SPACER
56. INTERMEDIATE GEARSHAFT NEEDLE BEARINGS
57. INTERMEDIATE GEAR BEARING SPACER
58. INTERMEDIATE GEAR
59. INTERMEDIATE GEARSHAFT NEEDLE BEARINGS
60. INTERMEDIATE GEAR BEARING SPACER
61. INTERMEDIATE GEAR THRUST WASHER

case as shown in Figure 17-5. Align the arbor tool in the intermediate gear assembly and remove the gear assembly and thrust washers.

Remove the front output shaft nut and washer. Remove the front output shaft yoke using a yoke-holding wrench and yoke puller as shown in Figure 17-6. Remove the front oil seal using a seal puller. Remove the cover plate attaching screws and remove the cover. Remove the front output shaft rear bearing. When removing the cover plate, do not damage the shims.

Remove the rear output shaft shift rail to the rear. Remove the output shaft shifting fork setscrew. Remove the poppet ball and spring plugs. Insert a punch through the pin hole in the rod and rotate the rear output shaft rod one-quarter turn counterclockwise and pull the rod out of the case.

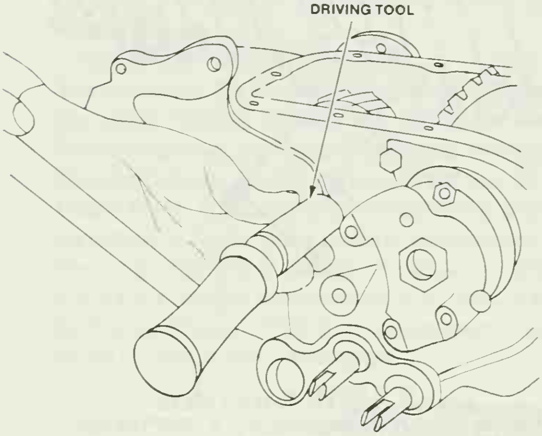


Figure 17-5. Removing the intermediate shaft with a driver.

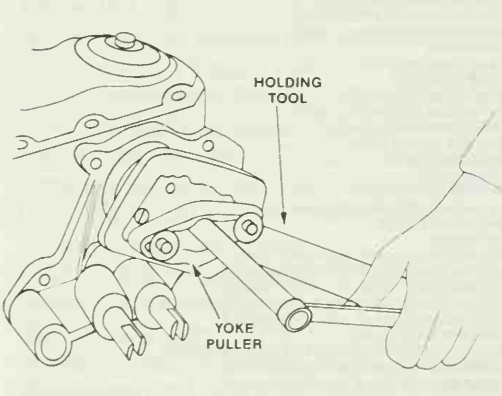


Figure 17-6. The yoke is removed with a yoke puller and holding tool.

Remove the front shift rod housing attaching screws and slide the housing off the remaining shift rail. Remove the rear output shaft sliding gear and shifting fork. Using a hammer and brass drift drive the front output shaft out the rear of the case. Support the transfer case on wood blocks when removing the shaft. Remove gears, spacer, and bearings from the case and rotate the shift rod to expose the setscrew. Remove the setscrew and pull out the shift rod.

Remove the shift rail thimbles using a brass drift to drive thimbles from the case. Remove the arbor tool, thrust washers, spacers, and roller bearings from the intermediate gear. Remove the front output shaft front bearing cup using the brass drift and hammer. Remove the shift rod seals from the housing. Remove the front output shaft rear bearing. Use the sliding gear as a support. Mount the gear in a vise with the shaft lever groove facing downward. Insert the front output shaft through the gear splines and drive the shaft out of the bearing using a brass drift and hammer.

Wash all the transfer case components and transfer case housing in solvent and allow to air-dry. Clean the gasket material from all the gasket surfaces. Inspect all the bearings, thrust washers, shafts, and gears for excessive wear, pitting, and scoring. Replace any part that is damaged or worn.

JOB COMPETENCY 17-5 REASSEMBLE A TRANSFER CASE

Install the front output shaft front bearing cup in the case. Seat the cup flush with the exterior surface of the case. Install the shift rail thimbles. Install the shift rod housing. Tighten the attaching bolts to the specified torque. Support the front output shaft rear bearing on a socket and install the shaft into the bearing using a brass drift and hammer. Install the front output shaft shift rail poppet ball and spring.

Compress the ball and spring and install the front output shift rail part way in the case. Install the front output shaft shifting fork with the setscrew facing the front of the case and slide the shift rail through the shifting fork. Align the setscrew holes in the fork and rail

and install the setscrew. Tighten the setscrew to the specified torque.

Install the front output shaft front bearing, bearing spacer, front output shaft sliding gear, and front output shaft gear. Be sure the shifting fork groove in the sliding gear faces the rear of the case. Install the front output shaft through the gears, spacer, and bearing. Support the case on wooden blocks and drive the front output shaft into the front housing using a brass drift and hammer. Be sure the bearing is seated against the shoulder on the front output shaft.

Install the front output shaft rear bearing cup using a wooden block and hammer. Install the rear bearing, cover plate, and shims. Tighten the cover plate bolts to specified torque.

The front output shaft end play must be measured. Seat the rear bearing cup against the cover plate by striking the end of the front output shaft with a lead or plastic hammer. Mount a dial indicator on the front bearing cup and position the indicator stylus against the end of the output shaft as shown in Figure 17-7. Pry the shaft rearward and zero the dial indicator. Pry the shaft forward and observe the dial indicator reading. The end play should be correct when compared to specifications. If necessary, adjust the end play by adding or subtracting shims between the cover plate and case. If shims are added, seat the rear bearing cup before checking the end play.

Install the rear output shaft shift rail poppet ball and spring in the shift rod housing. Compress the ball and spring and install the rear output shaft shift rail part way in the case. Before installing the shift rail, be sure the front output shaft shift rail is in neutral and that the interlock is seated in the housing bore. Install the rear output shaft shifting fork and sliding gear. Be sure the shifting fork groove in the gear faces the rear of the case. Align the setscrew holes in the fork and rail and install the setscrew. Tighten the setscrew to the specified torque.

Assemble the intermediate gear rollers and spacers. Install the intermediate gear thrust washers in the case with the tabs aligned in grooves in the case. The rear

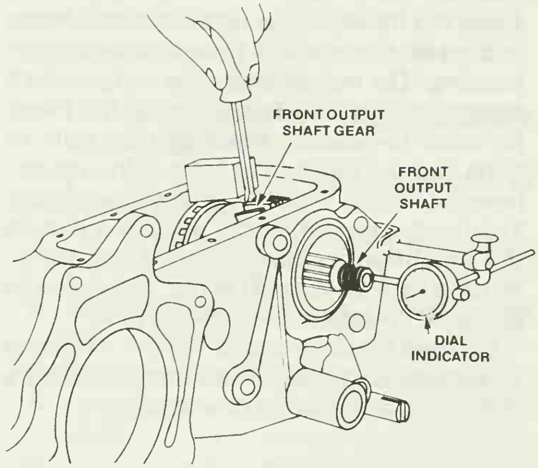


Figure 17-7. Checking front output shaft end play.

washer can be held in place by starting the intermediate shaft into the case. Hold the front washer in position with petroleum jelly. Install the O-ring on the intermediate shaft and install the intermediate gear in the case. Using a rawhide mallet or lead hammer, drive the intermediate shaft into the intermediate gear, forcing the **arbor driving tool** out of the front of the case.

Install the intermediate shaft lock plate, lock washer, and bolt. Tighten the bolt to the specified torque. Install the rear bearing cup assembly using a new gasket and slide the rear output shaft through the gear. Tighten the bearing cup bolts to the specified torque. Install the front yoke seal with the correct size driver. Install the front drive shaft yoke and tighten the locknut to the specified torque. Install the bottom cover and gasket. Tighten the bolts to the specified torque. Install the shift rod oil seals. Fill the unit with the recommended type and amount of lubricant through the filler plug.

JOB COMPETENCY 17-6
INSTALL A TRANSFER CASE IN A VEHICLE

Raise the transfer case up under the vehicle and install the transfer case on the adapter housing. Do not damage the output shaft splines during installation. Install the transfer case-to-adapter housing stud nuts or bolts. Tighten the nuts or bolts to the recommended torque. Install the rear crossmember. Tighten the crossmember attaching nuts to the specified torque. Remove the transmission jack or support stand. Connect the gearshift linkage to the transfer case.

Connect the drive shafts. Tighten the clamp strap bolts to the specified torque. Install a new O-ring on the speedometer adapter and install the adapter and cable in the transfer case. Do not attempt to reuse the old adapter O-ring. The O-ring is designed to "swell" in service to provide improved seating qualities and could be cut or torn if reinstalled.

Install the skid plate (Figure 17-8). Connect the catalytic converter or any exhaust pipes removed earlier. Check and adjust the transfer case lubricant level and transmission linkage adjustments if necessary. Lower the vehicle and road-test for proper operation.

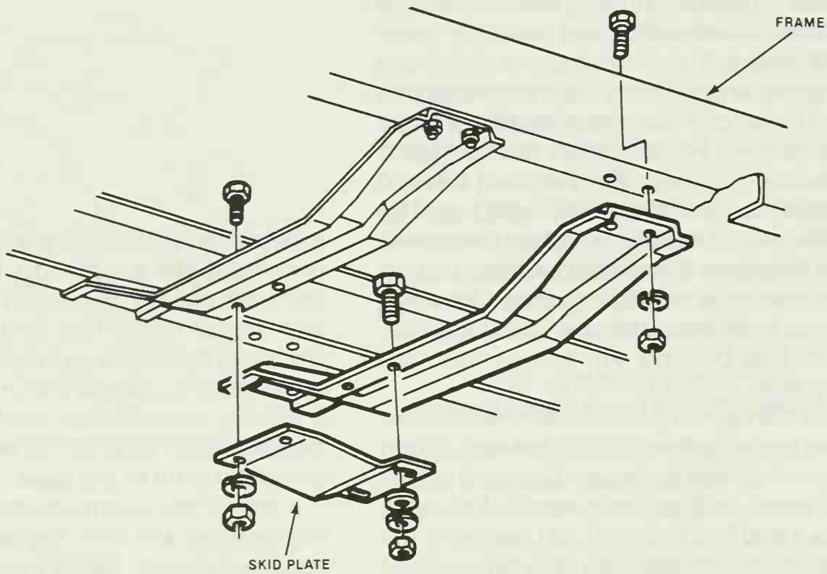


Figure 17-8. The skid plate is installed after the transfer case is in place.(GMC Truck and Coach Division of General Motors Corporation)

NEW TERMS

Adapter Component on the rear of the transmission that provides the mount for the transfer case.

Arbor driving tool A tool used to push parts together.

Skid plate Heavy metal plate mounted on the bottom of the vehicle to prevent damage in rough terrain.

JOB COMPETENCY TEST

1. Describe how to check a transfer case lubricant level.
2. Explain how to drain and refill the lubricant in a transfer case.
3. List two conditions which indicate a transfer case problem.
4. List two causes of excessive noise in a transfer case.
5. List four causes of shifting difficulties in a transfer case.
6. Describe how to remove a transfer case from a vehicle.
7. Describe how to remove a drive yoke.
8. Describe how to remove an intermediate shaft.
9. Explain how to measure front output shaft end play.
10. Describe how to install a transfer case.

CERTIFICATION PRACTICE

1. The lubricant is removed from a transfer case by removing:
   a. Drain plug
   b. Power take-off plate
   c. Bolt in the rear bearing retainer
   d. All the above
2. A transfer case has shifting problems:
   Mechanic A says the linkage may be at fault.
   Mechanic B says there may be a binding inside the case.
   Who is correct?
   a. Mechanic A
   b. Mechanic B
   c. Both Mechanic A and Mechanic B
   d. Neither Mechanic A nor Mechanic B
3. Excessive noise in a transfer case may be caused by:
   a. Low lubricant level
   b. Misalignment of drive shafts
   c. Both a and b
   d. Neither a nor b
4. Prior to removal of the transfer case, the mechanic must remove:
   a. Skid plate
   b. Adapter bolts or nuts
   c. Drive shafts
   d. All the above
5. The output shaft yokes are removed with:
   a. Puller tool
   b. Holding tool
   c. Both a and b
   d. Neither a nor b

ANSWERS:

1. d, 2. c, 3. c, 4. d, 5. c

DISCUSSION TOPICS AND ACTIVITIES

1. Drive a four-wheel drive vehicle with a transfer case malfunction and try to determine the cause of the problem.
2. Disassemble and reassemble a shop transfer case.

TRANSFER CASE TECH CHECK

Possible Cause	Service
Excessive noise	
1. Lubricant level low	1. Fill as required
2. Worn or damaged bearing	2. Replace
3. Worn or damaged chain	3. Replace
4. Misalignment of drive shafts or universal joints	4. Align
5. Yoke bolts loose	5. Torque to specs
6. Loose adapter bolts	6. Torque to specs
Shifter lever difficult to move	
1. Dirt/ contamination on linkage	1. Clean and lubricate
2. Binding inside transfer case	2. Repair as required
Shifter lever disengages from position	
1. Linkage misadjusted/loose	1. Readjust/tighten
2. Gears worn or damaged	2. Replace
3. Shift rod bent	3. Replace
4. Missing detent ball or spring	4. Replace
Lubricant leaking	
1. Excessive lubricant in case	1. Adjust level
2. Leaking seals or gaskets	2. Replace
3. Loose bolts	3. Tighten
4. Scored yoke in seal contact area	4. Refinish or replace

NATIONAL INSTITUTE FOR AUTOMOTIVE SERVICE EXCELLENCE

CERTIFIED

Unit 18
On The Job

If you have enjoyed studying about and working with power train components, you may wish to consider a career in power train technology. A power train mechanic or technician performs preventive maintenance, troubleshoots problems, disassembles components, makes necessary repairs, then reassembles the power train components.

TYPES OF CAREER OPPORTUNITIES

A power train mechanic may work in an automobile **dealership** or in an **independent garage.** A new-car dealership (Figure 18-1) is a business organized to sell and service new automobiles. In a dealership, a number of service personnel prepare new automobiles for sale by checking and adjusting them and adding any accessories that have been ordered. Since the warranty on a new vehicle specifies that it must be serviced and inspected at an authorized dealership, much power train service is done at dealerships.

Figure 18-1. A new-car dealership.

An independent garage (Figure 18-2) is a service facility that is not affiliated with any automotive manufacturer. Independent garage operations may be organized to service the total vehicle, or just one specific component. Many service stations (Figure 18-3) have an independent service operation.

There are many different service jobs in both dealerships and independent garages. The automobile **detailer** prepares automobiles for sale or delivery to a customer. This job includes washing and waxing the outside of the automobile as well as cleaning and vacuuming the inside. An automobile

Figure 18-2. Many power train mechanics work in independent garages.

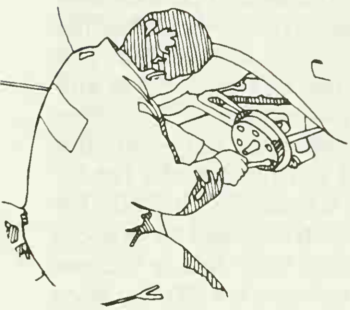
Figure 18-3. Power train components may be serviced in a service station.

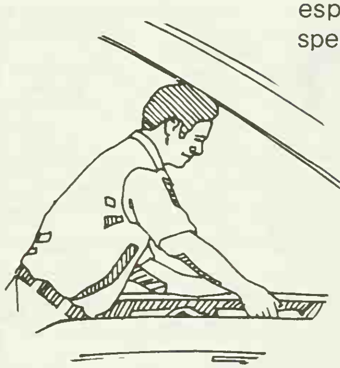
cleaner may be called upon to steam clean and paint engine compartments.

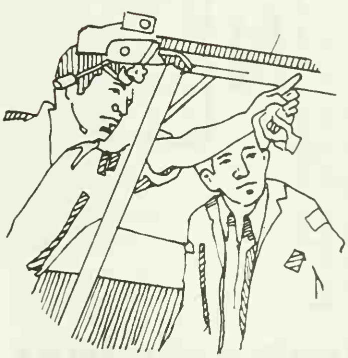
The job of the **lubrication specialist** is to lubricate chassis components, drain and replace engine oil, and check fluid and oil levels in the transmission, differential, power steering, and brake systems. The lubrication specialist must know exactly where lubrication is required and what kinds of lubricants to use. Frequently, the lubrication specialist is required to make a thorough inspection of other parts, such as the battery, radiator, radiator hoses, fan belts, exhaust system, tires, and brakes.

A **line mechanic** (Figure 18-4) may service any part of the automobile. Light repair usually refers to minor types of service such as installation of accessories, predelivery inspection of new automobiles, and replacement of parts such as fan belts and radiator hoses. A line mechanic who does heavy repair may work on a variety of different vehicle components. This job involves measuring, disassembling, machining, reassembling, and adjusting complicated components such as engines, transmissions and differentials. Such a mechanic has the very difficult task of learning about many different components and systems, and keeping up to date on industry changes in these components and systems.

As the automobile has become more complex, it has become difficult for the mechanic to keep up with all the changes. As a result, many mechanics now work in only one area of service. The **specialist mechanic** usually has advanced training and a great deal of experience in a certain service area. We can expect the area of power train service, especially transaxle service, to become a speciality area with great career opportunity.







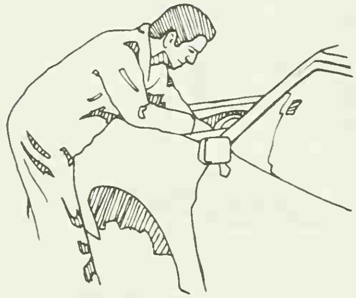


Figure 18-4. The power train line mechanic on the job. (Motor Vehicle Manufacturers Association)

Hard working and experienced mechanics may advance into supervisory positions such as **shop foreman, service writer,** or **service manager.** The shop foremen is in charge of mechanics in a service department, and must schedule the work and make sure it is done correctly. The service writer greets customers and discusses their automobile problems, then prepares the cost estimates and billing required to get the needed service performed. The service manager is responsible for all the different service departments in a large garage or dealership.

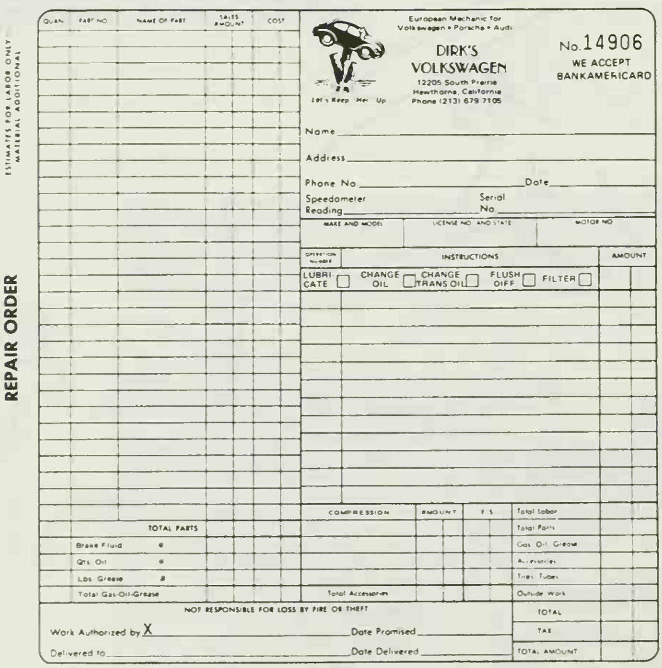
A DAY ON THE JOB

If you are considering a career in power train technology, you may be interested in reading a description of a typical day on the job. As our example, we will use a customer who brings a car into the shop with a complaint about a noise in the transmission area. In larger shops, the customer is greeted by the service writer or service advisor. In a smaller shop, the mechanic may greet the customer.

The mechanic or service writer listens to the customer's description of the car's problem. The mechanic may have had previous experience with this same problem. If not, the mechanic might go for a test ride with the customer and listen to the noise. The mechanic may wish to take along a troubleshooting guide for the vehicle to help determine the cause of the problem.

After test driving or listening to the customer's complaint, the mechanic next discusses the details of the repair with the customer. In many shops, this means filling out a repair order (Figure 18-5). A repair order describes the probable cause of the problem and the repair procedure.

The estimated total cost of repair is divided into costs for parts and labor. For, example, let's say the transmission noise indicates that the transmission must be overhauled. The estimated cost of the overhaul parts and labor is listed on the estimate. The labor estimate is the estimated charge for the mechanic's time in performing the repair. Most shops have a standard hourly rate for labor. If the transmission overhaul takes about six hours and the shop labor rate is $25 per hour, the labor cost estimate is $150. The labor


REPAIR ORDER

ESTIMATES FOR LABOR ONLY
MATERIAL ADDITIONAL

QUAN. | PART NO. | NAME OF PART | SALES AMOUNT | COST

European Mechanic for
Volkswagen • Porsche • Audi

DIRK'S
VOLKSWAGEN
12205 South Prairie
Hawthorne, California
Phone (213) 679 7105

Let's Keep Her Up

No. 14906
WE ACCEPT
BANKAMERICARD

Name
Address
Phone No. Date
Speedometer Reading Serial No.

MAKE AND MODEL | LICENSE NO. AND STATE | MOTOR NO.

OPERATION NUMBER | INSTRUCTIONS | AMOUNT

LUBRICATE ☐ CHANGE OIL ☐ CHANGE TRANS OIL ☐ FLUSH DIFF ☐ FILTER ☐

TOTAL PARTS
Brake Fluid @
Qts. Oil @
Lbs. Grease @
Total Gas-Oil-Grease

COMPRESSION | AMOUNT | P.S.
Total Accessories

Total Labor
Total Parts
Gas Oil Grease
Accessories
Tires Tubes
Outside Work
TOTAL
TAX
TOTAL AMOUNT

NOT RESPONSIBLE FOR LOSS BY FIRE OR THEFT

Work Authorized by X Date Promised
Delivered to Date Delivered

COPIES White Office Yellow Customer Pink Shop

Figure 18-5. A repair order lists the parts and labor for a repair job. (Dirk's Volkswagen)

and parts are totalled at the bottom of the repair order. If the customer agrees to have the work done, he or she signs the estimate and authorizes the work. If, when doing the job, the mechanic finds additional items requiring repair, the customer is called for approval.

With the repair job estimated and authorized the mechanic can start the repair. The car is moved to the mechanic's work area (Figure 18-6). (In larger shops, all mechanics have separate work areas with their own hand tools and specialized equipment supplied by the shop.) The mechanic may wish to study the detailed service procedure for the transmission to be serviced in a service manual. With tools and service manual in hand, the mechanic removes the transmission. A good mechanic is careful to observe all safety precautions while performing a repair.

When the transmission is removed, the mechanic carefully disassembles it, usually on a workbench. Each part is cleaned and inspected for wear. A detailed list is made of each defective part. The mechanic then orders the parts. Most dealerships stock the parts in the shop. Smaller shops have parts delivered or pick up parts. If the mechanic finds any defective parts not covered by the estimate, the customer is called for an authorization.

When the parts arrive, the mechanic starts the step-by-step assembly. A good mechanic maintains a clean work area to make sure dirt does not get into the overhaul. As the parts are assembled, necessary measurements are made and the service manual is consulted frequently.

The overhauled transmission is filled with oil and reinstalled in the car. After installation, the mechanic test drives the car and makes sure it works properly. If everything checks out, a bill or invoice is completed. The invoice lists the parts and labor to complete the repair job. The car is cleaned and parked in the shop parking area. The customer is called and informed that the car is ready. The mechanic is free to start the next job.

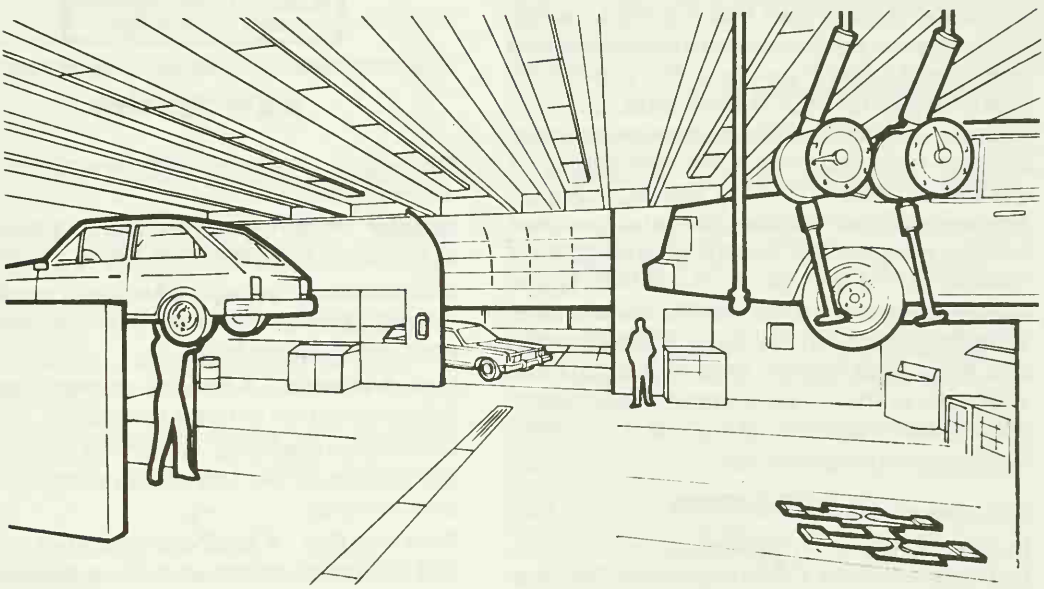


Figure 18-6. Mechanics usually have their own work areas. (Motor Vehicle Manufacturers Association)

PREPARING FOR A CAREER

If you are interested in automobiles and like working on them and studying about them, you could consider a career in automotive power train technology. In making any kind of career choice, you must be sure that you are interested in and want to do the kind of work involved in that career. The best way to try out a career is by working in a cooperative program, or by working part time or during the summer. If you are already a general automotive mechanic, you might consider retraining for automotive power train technology.

There are many things you can do to prepare for a career. First, try to learn all you can about careers. Look through the books in your school or local library. Talk to people who work in areas you are interested in. Find out the good and bad things about their jobs. Talk to the many people that can help you find out about a career. Your automotive instructor can help. Your school counselor also knows about careers. Remember that different careers require different skills and interests. Before you make a final career choice, have your teachers and counselors help you decide if you have the right skills and interests for your chosen field.

Once you make the decision to become a power train technician, the next step is to get the necessary training and experience. This usually means either a formal automotive training program, on-the-job apprenticeship training, or a combination of the two. There are automotive training opportunities in high schools, community colleges, trade schools, and the armed forces. Apprenticeships are available in the dealerships of major automotive manufacturers, as well as in independently owned repair shops.

CERTIFICATION

In the 1970s, an organization called the National Institute For Automotive Service Excellence (NIASE) recognized the increasing complexity of the automobile, and sought also to recognize the talents of mechanics who service them. NIASE developed a series of voluntary tests for the different automotive service areas. A mechanic working in one of the service areas or a student mechanic preparing for a career in one of the service areas may elect to sign up for a certification test.

When the test is passed, the mechanic is awarded certification and may wear the certified mechanic patch. (Figure 18-7) Certification indicates professionalism and the recognition of talent by fellow mechanics and employers. A certified mechanic takes pride in workmanship. Certified mechanics are sought out by car owners to repair their vehicles. If you are planning a career in this field, you should consider certification.

Figure 18-7. Certification patch for NIASE. (NIASE)

NEW TERMS

Dealership A place where new automobiles are sold and serviced.

Detailer A worker who cleans an automobile to prepare it for sale or delivery to a customer.

Independent garage An independently owned service business that may service any type of automobile.

Line mechanic A service worker who may service any part of the automobile.

Lubrication specialist A service worker who specializes in the lubrication of automotive components.

Parts supplier A business organized to stock and sell replacement parts for automobiles.

Service station A service business organized primarily to sell gasoline and oil but which usually has a repair operation as well.

Specialist mechanic A mechanic who specializes in the repair of one component, such as brakes or transmissions.

Glossary

A

Actuating rod Long, round metal rod used to transfer mechanical motion.

Adapter Component on rear of the transmission that provides the mount for the transfer case.

Alignment The adjustment of parts to get them into the correct relationship.

Annular gear A gear which has internal teeth; same as a planetary ring gear.

Arbor driving tool A tool used to push parts together.

Arbor press Hydraulic tool used to push or pull on a part for disassembly or reassembly.

Axle A shaft used to transfer torque from the differential to a drive wheel.

Axle bearing A bearing used to support an axle shaft in a housing.

Axle end play The in and out movement of the axle shaft when it is installed in the housing.

Axle shims Shims placed between the axle housing and outer axle bearing retainer used to adjust axle end play.

Axle side gears A gear in the differential case used to drive the axle.

B

Backlash The space or clearance between the teeth of the drive pinion and ring gear.

Ball stud A rod with a round bearing joint at one end.

Bearing retainer A press or bolt-on device used to hold a bearing in position.

Belleville spring A round disc that flexes when pushed in the middle.

Bleeding A procedure used to remove air from a hydraulic clutch assembly.

Boot Flexible rubber covering used to keep dirt out of a part.

Brass drift A tool made from soft brass, used to drive on a machined part.

Brinnelled A surface condition in which the metal begins to break apart.

Bushing A full circle bearing usually pressed into a part.

C

Cable-operated clutch linkage Clutch linkage operated by a flexible metal cable.

Cam An eccentric shaped device used to change rotary to up and down motion.

Cardan joint Same as a constant-velocity universal joint.

Carrier Housing in which the drive pinion and case assembly are mounted.

Case Differential component used to mount the ring gear, axle side gears, and differential pinions.

Case runout The amount of runout on the ring gear mounting surface of a case.

Center support A bearing assembly mounted around the drive shaft and attached to the vehicle chassis to support the drive shaft.

Circlips Self-locking rings that fit into a machined groove.

Clevis A forked shape unit used to join linkage together.

Clutch Device used to couple and uncouple the engine from the power train.

Clutch chatter A shaking or shuddering of the vehicle as the clutch is operated.

Clutch cover Part of the pressure plate assembly bolted to the flywheel.

Clutch disc Driven member of clutch assembly splined to the transmission input shaft.

Clutch disc aligning tool A tool used to line up the clutch disc with the pressure plate during assembly.

Clutch drag A problem in which the clutch disc does not come to a complete stop after the clutch pedal is depressed.

Clutch fork Unit is used to connect the clutch linkage to the release bearing.

Clutch linkage Rods, cables or hydraulic lines used to actuate the clutch.

Clutch slippage A condition in which the engine overrevs during shifting or acceleration.

Coil-spring pressure plate Pressure plate assembly that uses coil springs to engage the clutch disc.

Column shift linkage Shifting fork control linkage mounted to the driver's steering column.

Cone-clutch A limited-slip differential clutch that uses coned surfaces on the axle side gears and the case.

Constant-mesh gear A gear set in which the gears are always engaged.

Constant-velocity universal joint A universal joint constructed from two universal joints connected by a centering yoke and used when the operating angle is too large for a single universal joint.

Control linkage The floor or steering column linkage used by the driver to select the transmission gears.

Countershaft System of gears mounted in the transmission below the mainshaft.

Coupling yoke A component used to connect parts to a universal joint assembly.

Cradle A subframe on the bottom of the engine compartment used to support the transaxle assembly.

D

Dealership A place where new automobiles are sold. Most dealerships also have a service operation.

Detailer A service worker who cleans an automobile to prepare it for sale or delivery to a customer.

Detent A ball or roller used to lock a component into position.

Diagnosis guide Chart provided by a manufacturer listing problems and possible causes.

Diaphragm-spring pressure plate A pressure plate that uses a diaphragm or Belleville spring to push against the disc.

Differential A system of gears in the rear axle assembly that allows the rear wheels to turn at different speeds when cornering.

Differential bearing end-play The amount of side to side movement of the differential case controlled by shims between bearings and housing.

Differential case bearing preload Preload on the differential case bearings adjusted with shims under the bearing cups.

Differential housing installation angle The angle between true horizontal and the pinion shaft when installed in the vehicle.

Differential pinion gears Small gears in the case in mesh with the axle side gears.

Differential ring gear The gear in the differential that meshes with the drive pinion gear.

Double Cardan universal joint Same as constant-velocity universal joint.

Drain plug Drain plug used to remove lubricant from a transmission.

Drive axle A shaft that transfers power from the differential to the driving wheels.

Drive line assembly The parts used to transfer the engine's power from the transmission to the rear axle assembly.

Drive pinion A gear in the differential connected to the drive shaft.

Drive shaft A large steel tube used to transfer the engine's power from the transmission to the rear axle assembly.

Drive shaft assembly The parts used to transfer engine power from the transmission to the rear axle assembly.

Drive shaft out of balance A condition caused by a bent, dirty, or undercoated drive shaft that shows up as a vibration.

Drive shaft runout A condition in which the drive shaft wobbles as it turns.

Drive yoke A part used to connect power train parts.

Dry-disc clutch Clutch in the driven disc does not operate in a fluid.

Dummy shaft Shaft installed in place of countergear shaft to hold bearings in place.

E

Engine support A bar or pipe which is installed over the engine to hold it up when the transaxle is removed.

F

Facings Friction material attached to both sides of the clutch disc.

Filler plug Plug inside the transmission, used to fill the unit with lubricant.

Flexible joints Joints on a front-drive axle which allow the front wheels to turn and go up and down with the suspension.

Floating gear A gear attached to a shaft other than the input or output shaft.

Floor shift linkage Shifting fork control linkage mounted to the floor next to the driver.

Flywheel A large wheel driven by the engine, used as a frictional and driving part of the clutch.

Four-speed transmission A transmission with four forward speeds or gear ratios.

Four-wheel drive A drive arrangement in which all four wheels receive power from the engine.

Free play Movement of linkage that does not result in movement of the connecting part.

Free running clutch hub A type of hub used with part time four-wheel drive in which the drive axle may be engaged or disengaged from the hub.

Freewheel To overrun or turn without allowing power to be transmitted.

Front-drive transaxle A transaxle system located at the front of the vehicle and providing a drive to the front wheels.

Front-wheel drive A drive arrangement in which the front wheels of the vehicle provide the drive.

Full-floating axle An axle system in which all the vehicle weight is supported through a hub to the housing and no weight is supported by the axle.

Full-time transfer case A transfer case that provides four-wheel drive under all road conditions.

G

Gear A wheel with teeth used to engage or mesh with another wheel with teeth to act as a lever.

Gear ratio The ratio of the number of teeth on two gears that are in mesh with each other.

Gear tooth contact pattern The area of contact between the drive pinion and ring gear.

Governor speed switch Electric switch connected to the speed-sensing mechanism.

H

Hotchkiss drive A type of drive line assembly using two or three universal joints and an open drive shaft.

Housing misalignment A condition in which the clutch housing is not in alignment with the other clutch components.

Hunting gear A gear that meshes with another gear with different teeth each revolution.

Hydraulic clutch linkage Clutch linkage utilizing hydraulic fluid to transfer movement at the clutch pedal to the clutch assembly.

Hydraulic pressure test An overdrive test in which a pressure gage is connected to the hydraulic system to determine pressures.

Hypoid gears Drive pinion and ring gears with a gear shape that allows them to mesh off center.

I

Idler gear A gear that idles or floats between two other gears to provide a directional change in power flow.

Inboard joint The inside joint on a front-drive axle which allows for front wheel up and down movement.

Independent garage An independently owned service business that may service any type of automobile.

Independent rear suspension A type of rear suspension in which the differential assembly is solidly mounted to the chassis and drive axles with universal joints that deliver power to the drive wheels.

Integral differential A differential assembly in which the case assembly is not removable from the carrier.

Interlocks A system of detent plugs that prevents shifting forks from engaging two gears at one time.

Internal gear A gear wheel with teeth on its inside diameter.

J

Journal A round bearing surface.

L

Line mechanic A service worker who may service any part of the automobile.

Limited-slip differential A differential assembly with cone or multiple disc splined to the axle side gears and the case.

Locating gage Tool used to adjust shift linkage.

Locked hub A type of four-wheel drive hub in which the axle is splined directly to the hub and provides a positive lockup at all times.

Lubrication specialist A service worker who specializes in the lubrication of automotive components.

M

Mainshaft A shaft that supports a system of gears mounted above the countershaft gear assembly.

Mainshaft end play Movement end to end of the mainshaft controlled with shims under the end of the shaft.

Manual clutch Clutch operated by a driver-controlled foot pedal

Manually operated transmission A transmission that is shifted from one speed to another by the driver.

Mechanical clutch linkage A series of rods, bellcranks, or cables used to connect the clutch pedal to the clutch assembly.

N

Nominal dimension A standard measurement between the end of the pinion and the axle center line used to calculate pinion depth.

O

Operating-angle gage A protractor tool used to measure the universal joint operating angle.

Outboard joint The outside joint on a front-drive axle which allows the front wheels to turn back and forth.

Output shaft of the transmission Shaft on which the torque from the transmission exits.

Overdrive system A system of gears used to allow the transmission output shaft to turn faster than engine speed.

Overrunning clutch A clutch used in a planetary overdrive to disconnect the engine from the transmission output shaft.

P

Parts supplier A business organized to stock and sell replacement parts for automobiles.

Part-time transfer case A transfer case that allows the driver to select two- or four-wheel drive by shifting gears in the case.

Pattern chart Chart showing typical gear tooth contact patterns.

Pedal freeplay The free movement of the clutch pedal before the throwout bearing works the release levers.

Pedal height The distance from the floor to the top of the clutch pedal.

Pedal pulsation A rapid up and down movement of the clutch pedal during operation.

Pedal travel Same as pedal free play.

Pilot bushing A bushing or bearing used to support the transmission input shaft in the flywheel or crankshaft.

Pinion a type of small round gear wheel which meshes with a larger gear to transmit torque.

Pinion bearing preload Preload on the pinion bearings adjusted with shims between the pinion shaft and the case.

Pinion depth The position of the drive pinion in relation to the axle center line.

Pinion marking Etched marking that identifies pinion match to ring gear and shows desired pinion depth.

Pinion preload The amount the pinion shaft nut is tightened to preload the pinion bearings. Measured with a torque wrench.

Pinion shaft yoke A connecting part attached to the pinion shaft.

Planetary gear system A gear system consisting of a sun gear, planet gears, planet carrier, and ring gear, used to achieve an overdrive.

Planetary ring gear A gear in a planetary gear set with internal gear teeth.

Planets Small pinion gears used in a planetary gear set in mesh with the sun and ring gears.

Positraction A differential assembly which uses clutches in the carrier for improved traction.

Power The speed or rate of doing work.

Power flow The path of power through a power train component.

Power train The system which delivers the power of the engine to the vehicle's drive wheels.

Pressure gage set Gages installed in overdrive pressure ports to measure operating pressure.

Pressure plate The part of the clutch that pushes the clutch disc against the flywheel.

Pressure plate fingers Same as release levers.

Propeller shaft Same as drive shaft.

R

Rear-drive transaxle A transaxle system located at the rear of the vehicle and providing a drive to the rear wheels.

Rear-wheel drive A drive arrangement in which the rear wheels are used to drive the vehicle.

Release bearing A bearing and sleeve assembly used to push against the pressure plate release mechanism to disengage the clutch.

Release fork Same as clutch fork.

Release levers Levers on the pressure plate assembly used to remove spring pressure from the clutch disc.

Remote reservoir Reservoir mounted away from a hydraulic cylinder.

Removable carrier A type of differential assembly in which the carrier may be removed from the axle housings.

Reverse idler gear A small gear used to change the direction of output shaft rotation for reverse.

Ring and pinion gear ratio The ratio between the drive pinion and the ring gear in the differential.

Ring gear See differential ring gear and planetary ring gear.

S

Seal driver Tool used to drive new seal in place.

Seal puller Tool used to pull old seal out of a housing or case.

Semi-centrifugal clutch Type of clutch that uses weighted release levers that increase clutch holding force at high engine speed.

Semifloating axle An axle system in which the axle supports the vehicle weight as well as driving the wheel.

Service station A service business which is organized primarily to sell gasoline and oil but which ordinarily has a repair operation as well.

Service writer Technician who writes repair estimates and invoices.

Shift fork, shifting fork Linkage-operated part used to operate transmission synchronizers.

Shift rail Shafts used to guide shift linkage movement.

Side adjusters Threaded adjusters on each side of a removable carrier case used to set backlash.

Side gears Same as axle side gears.

Single dry-disc clutch Type of manual clutch that uses one dry clutch disc.

Skid plate Heavy metal plate mounted on the bottom of the vehicle to prevent damage in rough terrain.

Slave cylinder Hydraulic device used to move the clutch release bearing.

Sliding clutch A clutch applied by hydraulic pressure used to engage and disengage a planetary overdrive.

Slip joint The part of the drive assembly that allows for a change in length as the vehicle goes over rough surfaces.

Solenoid A magnetic switch.

Specialist mechanic A mechanic who specializes in the repair of one component, such as brakes or transmissions.

Spline A long set of ridges or teeth used to transmit power between parts.

Spreader Tool used to spread the housing of a unitized carrier to remove the case.

Standard setting Same as nominal dimension.

Sun gear The center gear in a planetary gear system.

Synchronizer A cone clutch device that works to synchronize the speed of gears and shafts so they can be meshed without clashing.

T

Tapers Beveled surfaces.

Three-speed transmission A transmission with three forward speeds or gear ratios.

Thrust washer Washer used to take up free play when parts are under a load.

Torque Twisting or turning effort developed by the engine.

Torque multiplication The increasing of the turning effort of the engine to get the vehicle moving.

Torque tube drive A type of drive assembly that has the drive shaft enclosed in a tube called a torque tube.

Torsion springs Springs in the hub of the clutch disc that absorb torsional vibration.

Transaxle A component in which the transmission and differential assembly are combined in one unit.

Transfer case A system of gears in a housing behind the transmission that directs power to a front and rear drive axle.

Transmission System of gears used to multiply the turning effort of the engine.

Transmission installation angle The angle between true horizontal and the transmission output shaft when installed in the vehicle.

Transverse engine The mounting of an engine sideways in a vehicle.

Tripod A part of an inboard joint that supports three sets of bearing races and needle bearings.

U

Unitized carrier A carrier assembly that is not removable from the axle housings. Also called an integral carrier.

Unitized differential Same as integral differential.

Universal joint/(U-joint) The part of the drive line assembly that allows for a change in angle of the drive line as the differential moves up and down.

Universal joint operating angle The angle the universal joint operates on determined by the differential and transmission operating angles.

V

Vehicle identification number (VIN) Number and letter code used to identify the vehicle and its component parts.

VIN decoding chart Chart used to interpret the vehicle identification number.

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